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**Logistics Research Network
Conference 2023**

Supply Chain Sustainability

6 – 8 September 2023, Heriot-Watt, Edinburgh



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The LOGISTICS RESEARCH NETWORK (LRN) is an informal network of leading academics, researchers and practitioners supported by The Chartered Institute of Logistics and Transport.

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LRN's main objective is to facilitate the generation, promotion and dissemination of relevant research to professionals working across all sectors within the supply chain. The LRN 2023 Conference was based upon accepted abstracts and was an opportunity to meet and share research, and discuss sustainable and resilient supply chains in disruptive times.

This document features all submitted Full Papers for LRN 2023. The Chartered Institute of Logistics and Transport (CILT) is the independent international professional body for individuals and organisations associated with logistics and transport. It has over 33,000 members across more than 33 countries worldwide.

CILT(UK) provides knowledge, networks and know-how for individual and collective success; it is the essential professional body for talented leaders and organisations that create, manage and operate logistics, transport and supply chain capabilities.

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"I'm truly impressed with the variety of topics at LRN conference. We need to have more of these transdisciplinary events that bring together multiple communities to discuss these important themes".

**Prof Joseph Sarkis, Worcester Polytechnic Institute and
Hanken School of Economics**



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Welcome to the beautiful city of Edinburgh!

Welcome to the 27th Annual Conference of the CILT(UK) Logistics Research Network hosted by Heriot-Watt University. We are delighted to welcome you to the capital city of Scotland and the beautiful campus of Heriot-Watt University. Heriot-Watt University has a long tradition in the logistics and supply chain management field and is home to the internationally renowned Centre for Logistics and Sustainability.

This year's Conference theme is "Supply Chain Sustainability", a highly timely subject given the well documented challenges associated with the design and implementation of supply chains that are truly sustainable. We recognise that environmental sustainability is crucial in the context of global heating and the climate emergency but must also be mindful of the social and economic dimensions. This "triple bottom line" focus is reflected in the structure and content of LRN2023.

Innovation aimed at establishing sustainable supply chains starts with research. In this context, there is a need for academics to understand industry needs to be able to influence both the practice and theory of supply chain management, creating innovative models to help organisations to become more sustainable. This theme of academics and researchers working in partnership with business, industry and other key stakeholders is evident across the conference programme.

We have planned a number of plenary sessions involving a range of recognised logistics thought leaders. LRN was last hosted by Heriot-Watt University in 2001 when the event was chaired by the then Director of the University's Logistics Research Centre, Professor Alan McKinnon. We are thrilled that Alan will return to the University where he was based for 25 years to deliver the opening keynote address. His address will focus on logistics and climate, focussing on the question of how moving and storing stuff lies at the heart of our battle against climate change. This year marks the tercentenary of the birth of Adam Smith, the Scottish economist and philosopher and a key figure in the Scottish Enlightenment. Panmure House, Smith's final remaining home in the heart of Edinburgh's Old Town, is part of Heriot-Watt University's Edinburgh Business School. At LRN2022 at Aston University I teased delegates with the question "Was Adam Smith the Father of Supply Chain Management". I look forward to exploring this question at LRN2023 with my colleague Professor Adam Dixon, inaugural holder of Heriot-Watt University's Adam Smith Chair of Sustainable Capitalism, based at Panmure House. LRN2023 will also feature a panel discussion on sustainable logistics with panellists drawn from leading organisations in the UK and beyond, including the Centre for Sustainable Road Freight in which we at Heriot-Watt University are proud to play a central role. We are also delighted to welcome our colleagues from the Defence Science and Technology Laboratory (dstl) - "the science inside UK defence and security" - who will share their perspectives on supply chain sustainability.

We are also delighted to introduce an innovative feature to LRN2023 - the "curiosity corners". This session will introduce a number of key logistics themes and initiatives which we believe are of interest to conference delegates. These include sustainable road freight, logistics in rural and island communities, and the supply chain talent challenge. These sessions will be facilitated by Generation Logistics, the Scottish

Rural and Islands Transport Community (SRITC), the Defence Science and Technology Laboratory (dstl) the Centre for Sustainable Road Freight, the International Journal of Logistics Research and Applications and CILT Scotland. The format is designed to provide delegates with an overview of these themes with the opportunity to explore one or more of them in more detail.

One of the key objectives of LRN is to promote and celebrate excellence in logistics research. With this in mind, we will be continuing with our best paper awards. One will focus on research quality with the other recognising effective societal and economic impact. We will again be producing a conference special issue of the International Journal of Logistics Research and Applications which will showcase the very best research from LRN2023.

The conference attracted over 170 abstracts covering a good cross section of topics relevant to both the conference theme and logistics more generally. The papers presented at LRN2023 will showcase the latest research in a wide range of topics in the area of supply chain management and logistics from sustainability, circular economy, ethical considerations through to the effective deployment of existing and emerging tools and technologies.

Finally, I wish to extend my personal thanks to: my Heriot-Watt colleagues Florian Scheuring, Claire Lindsay, Charlotte Rutherford, Senlei Wang and Naila Fares for their work in curating and planning LRN2023; numerous other Heriot-Watt colleagues (too many mention individually!) who supported us with the reviewing process; the CILT team, particularly the indefatigable Alli Glandfield, for their guidance, support and patience; and, the LRN Forum committee, ably led by Professor Vasco Sanchez Rodrigues, for giving us the opportunity to host this important event.

My colleagues and I hope that you find LRN2023 both interesting and enjoyable. We look forward to welcoming many old friends to Heriot-Watt, as well as to meeting new friends as we explore the many exciting challenges with which we are grappling in the quest to build the sustainable supply chains of the future.



Edward Sweeney

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ROLE OF EXTERNAL PRESSURE IN ADOPTING SUSTAINABLE SUPPLY CHAIN INITIATIVES TO ENHANCE ENVIRONMENTAL PERFORMANCE

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1. Introduction

Environmental pollution and waste accumulation have become a growing global concern due to the rapid economic development in emerging countries in the world (Hsu et al., 2016). The manufacturing industry accounts for approximately 70% of global industrial waste accumulated each year, which creates significant economic and environmental challenges for organisations and policymakers (World Bank, 2020). The supply chains associated with transforming raw materials into finished products possesses a substantial risk to the health and safety of individuals and also towards the economies of local as well as global environments due to the high resource consumption and waste generation (Hsu et al., 2013). Further, the attention of sustainable development goal on manufacturing sector amplified the environmental performance (EP) for a sustainable way forward (United Nations, 2023).

The absence of proper waste management systems in manufacturing facilities and in urban areas further degrades the damage caused to human health and to the environment as a whole (Dissanayake & Weerasinghe, 2020). Moreover, most of the manufacturing industries in developing countries handle waste by either sending it to incineration facilities or to landfills, which ultimately contributes to the depletion of resources, soil degradation, pollution of air, and water contamination (Pensupa et al., 2017; The World Bank, 2022). The question arises whether manufacturing organisations can handle the effect towards environmental performance and sustainability with the growth of the manufacturing sector on the local and global stage (Hsu et al., 2016).

To counter the severe issue of waste accumulation and environmental pollution organisations and policymakers of a nation should adopt sustainable manufacturing practices, such as recycling, reduction of using virgin materials, and implementing principles of circular economy (Mazibuko et al., 2019; Sandin & Peters, 2018; World Bank, 2020). Many scholars and practitioners have identified that the application of green or sustainable supply chain initiatives (SSCI) has proven the improvement of EP (Al-Ghwayeen & Abdallah, 2018; Dubey et al., 2017; Giovanni, 2012; Jabbour et al., 2015; Kung et al., 2012; Sudeeptha & Galahitiyawe, 2020; Zhu & Sarkis, 2007).

The theoretical base of sustainable supply chain management (SSCM) is at an infancy stage when considering the adoption of SSCIs in a way to achieve a circular economy with initiatives associated with reverse logistics such as green purchasing, green packaging, and green manufacturing (Svensson 2007; Carter and Rogers 2008; Seuring & Muller 2008; Gold et al. as cited in Morali & Searcy, 2013). For developing a theoretical base for the SSCM predominantly many scholars have used resource-based view, stakeholder theory, transaction cost theory and institutional theory (Touboulis & Walker, 2015). The current study will be adopting the stakeholder theory and institutional theory in exploring the observed practical and empirical gaps.

Stakeholder theory supports in understanding the nature of the relationships between different firms and the associated stakeholders and the beneficial performance outcomes of such relationships (Freeman, 1984; Jones et al., 2018). The theory suggests that organisations should focus and consider on the creation of value for the individual and groups who has a stake in organisations through the decision-making procedure (Freeman et al., 2004; Laplume et al., 2008). In the virtue of achieving a sustainable supply chain as a whole, one should consider all the shareholders, as well as their stakeholders, involved to achieve sustainability as a whole.

DiMaggio and Powell (1983) introduced the intuition theory, which explained that the external social pressure, which is either mimetic, coercive or normative will influence organisations to transform their practices and to adopt behaviours that are socially responsible to gain social legitimacy. Many previous studies have utilized the institutional theory to justify the adoption of green/sustainable business practices as a result of different external institutional pressure agents such as regulatory pressure (RP), customer pressure (CuP), competitor pressure (CoP) supplier pressure and employee pressure

(Hsu et al., 2016; Meixell & Luoma, 2015; Shafique et al., 2017; Sudeeptha & Galahitiyawwe, 2020; Zhu & Sarkis, 2007). To the best of the knowledge of the researcher, the literature has not focused much on the non-government organisational pressure on the firms in the application of sustainable practices through the lens of institutional theory.

Thus, the study focuses on empirically exploring the role of external pressure (ExP) in adopting SSCIs to enhance EP with the aid of literature related to SSCM and utilising institutional theory and stakeholder theory. The research study would be significant in extending the current literature related to SSCM and bridging the gap identified in institutional theory.

2. Research Problem and Objective of the Study

Most of the empirical studies that have been undertaken in the local and global context regarding waste generation and accumulation issue only address the waste management sphere rather than considering the application of SSCIs with the intention of reducing and eradicating waste generation by going for a circular economy (Dissanayake & Weerasinghe, 2020; Niesten et al., 2017; Sandin & Peters, 2018). The study by Morali and Searcy (2013) have implicated that the empirical exploration into the integration of sustainability principles in managing supply chains is very lacking in the literature related to SSCM. Further, research undertaken globally explores the initiation of SSCIs or green practices in developed countries leaving out the out in-depth empirical exploration into the outcomes or the antecedents of the business practices which are ecologically friendly in emerging economies (Al-Ghwayeen & Abdallah, 2018; Hsu et al., 2016). The exploration would be significant as emerging economies are seen as the epicentre of the manufacturing industry and its growth.

Thus, the objective of the research study is to explore avenues and relationships in adopting sustainable supply chain practices in enhancing EP in the manufacturing industry with an exploration into the moderation effect of external pressure.

3. Literature Review

The literature review reviews the significant literature in the areas of environmental performance, and a general overview of supply chain and sustainable supply chain initiatives.

3.1. Environmental Performance

EP can be defined as the ability of a manufacturing plant to reduce effluent waste, air emissions, solid wastes and decrease the usage of toxic and hazardous materials in the manufacturing process (Zhu et al., 2008). Similarly, EP is defined as an activity that essentially manages the impact on the natural environment as a result of a firm's strategic direction (Walls et al., 2012). The EP of an organisation has become critical as some customers and organisations consider EP as a selection criterion when selecting suppliers (Al-Ghwayeen & Abdallah, 2018). Thus, balancing the EP and the economic performance of firms has been a significant topic in handling competitive, community and regularity pressures (Al-Ghwayeen & Abdallah, 2018; Al-Sheyadi et al., 2019). In summation it means that EP focuses on protecting air quality, management of solid and other wastes and protection of pollution of the environment (Omar et al., 2016).

3.2. Sustainable Supply Chain Management and Its Initiatives

A supply chain is a chain which consists of all the parties involved either directly or indirectly to fulfil consumer requests (Chopra & Meindl, 2013). The parties involved in a supply chain spread from the initial raw material supplier to the ultimate end user. Similarly, in a supply chain: raw material suppliers, manufacturers, transporters, warehouses, retailers and even consumers are involved in supply chain processes (Govindan et al., 2014). In literature to discuss the sustainability aspect of supply chains the term SSCM and green supply chain management is commonly used (Ahi & Searcy, 2013). Through adopting SSCM practices firms can gain both economic and environmental benefits (Carter et al., 2000; Rao & Holt, 2005). In SSCIs include green purchasing, green manufacturing/production, green packaging, internal environment management, eco-design, investment recovery, green distribution, reverse logistics (Al-Ghwayeen & Abdallah, 2018; Alshura & Awawdeh, 2016; C. C. Hsu, Tan, & Zailani, 2016; Ninlawan et al., 2010; Villanueva et al., 2013). The SSCM practices try to reduce the environmental impact of the product throughout their life cycle (Zhu et al., 2005; Hendricks & Singhal, 2005; Navarro-García et al., 2016 as cited in Al-Ghwayeen & Abdallah, 2018) by focusing on the end of life practices that are defined by the "re's" of reuse, reduction, recycling and remanufacturing (Hervani et al., 2005).

3.3. Green Purchasing, Green Packaging and Green Manufacturing

Green purchasing, green manufacturing and green packaging can be considered as SSCIs that are designed to accomplish organisations' strategic supply chain functions by minimizing the negative impact on the natural environment (Hsu et al., 2016). Green purchasing can be defined as ecologically conscious purchasing initiatives that are aimed at procuring components and materials that meet the organisations' eco-friendly goals (Hsu et al., 2016). Green manufacturing is defined as environmentally friendly production with the goal of minimizing the detrimental effects towards the environment throughout the product's entire life cycle and also the promotion of ecological business practices: recycling and reusing products (Dam & Petkova, 2014). Green packaging can be defined as a process of packaging a product in an environmentally conscious way to minimize the negative environmental impacts associated with packaging (Hsu et al., 2016).

4. Conceptual Framework and Methodology

4.1. Conceptual Framework

The study empirically explores the influence of SSCIs towards the EP and attempt to understand the involvement of different stakeholders in exerting external social pressure. The institutional theory and stakeholder theory combinedly provide a theoretical explanation for the intended aims of the research. The study has developed the following conceptual framework and subsequent hypotheses to test after a rigorous literature reviewing process.

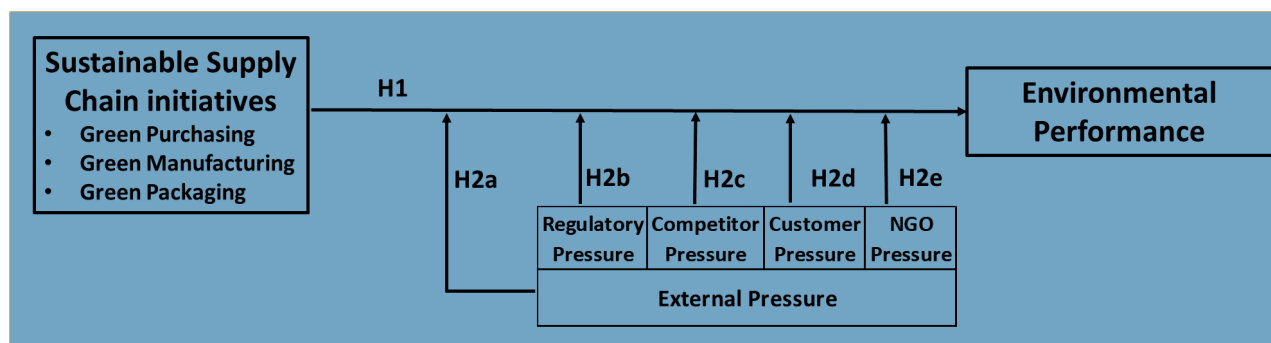


Figure 1: Conceptual Framework (Source: Author generated)

4.2. Methodology

The methodology was based on a positivistic, deductive, and quantitative approach. A structured questionnaire was utilised for the quantitative cross-sectional survey. The study sample included 143 manufacturing plants in Sri Lanka which have adopted at least one or more SSCIs. Preliminary SPSS was used for data analysis and for further analysis of data Structural Equation Modelling (SEM) was utilised with the use of SmartPLS. The researcher conducted a pilot study with 30 returned questionnaires and ensured the internal consistency of the instrument. Supply chain/Operations/Factory managers of manufacturing organisations were considered as the respondents of the study. A seven-point Likert scale (Strongly agree – strongly disagree) was used by respondents to measure all the constructs and variables of the study. SSCIs measurement items were adapted from Ninlawan et al. (2010), external pressure measurement items were adapted from Chu et al., (2018), Moosmayer et al. (2019) Sudeeptha and Galahitiyawwe (2020), and environmental performance measurement items were adapted from Al-Ghwayeen and Abdallah (2018).

5. Data Analysis and Results

This study has utilised a quantitative analysis to test the hypotheses of the study. In consideration of the returned 143 questionnaires, most of the organizations were from the apparel industry. The descriptive statistics, tests for common method bias and non-response bias using one-way ANOVA, normality, linearity and homoscedasticity, multicollinearity, unidimensionality, and reliability analysis were conducted. SPSS and structural equation modelling using the SmartPLS package have been used for the analysis. Sequentially the measurement model for lower-order components, and the measurement model for higher-order components were developed to assess the reliability and validity of the items. Then, the structural models were developed for hypothesis testing.

Hypothesis	Path	Path Coefficient	T Statistics	P Values	Decision
H₁	SSCI -> EP	0.583	8.226	0.000	Supported
Direct Effect	ExPr -> EP	0.197	2.274	0.023	Supported
H_{2a}	SSCI * ExPr -> EP	0.513	2.227	0.035	Supported
Direct Effect	RP -> EP	0.282	2.517	0.012	Supported
H_{2b}	SSCI * RP -> EP	0.194	2.617	0.00	Supported
Direct Effect	CoP -> EP	0.059	0.663	0.508	Not Supported
H_{2c}	SSCI * CoP -> EP	-0.046	0.644	0.520	Not Supported
Direct Effect	CuP -> EP	0.227	2.451	0.150	Not Supported
H_{2d}	SSCI * CuP -> EP	-0.032	0.484	0.625	Not Supported
Direct Effect	NgoP -> EP	0.171	2.424	0.012	Supported
H_{2e}	SSCI * NgoP -> EP	0.283	2.617	0.00	Supported

Table 1: Summary of the Hypothesis Testing (Source: Survey data)

As per Table 1, H₁ hypothesis which tests the impact of SSCI and EP is supported with a significant P value of 0.000. When considering the moderation effect of ExPr as a construct on the relationship between SSCI and EP is supported with a significant P value of 0.035. Further, the researcher analyzed to identify each dimensions moderation effect on the relationship between SSCI and EP, where it prevailed that RP moderates the relationship with a significant P value of 0.000, NgoP moderates the relationship with a significant P value of 0.000 and, CoP and CuP as a dimension does not satisfy the moderation relationship due to insignificant P value.

6. Discussion of Findings and Conclusion

Literature suggests that the application of sustainable business practices such as green/sustainable supply chain management practices enables organisations to achieve greater EP (Al-Ghwayeen & Abdallah, 2018; Hsu, Tan, & Mohamad Zailani, 2016; Zhu et al., 2008). Further many scholars have examined the adoption of sustainable supply chain practices as a result of pressure exerted from external parties such as regulatory bodies, customers, and competitors (Banerjee et al., 2003; Zhu & Sarkis, 2007; Sarkis et al., 2010; Zailani et al., 2012 as cited in Sudeeptha & Galahitiyawee, 2020; (Meixell & Luoma, 2015; Shafique et al., 2017) but not much extent into the pressure exerted by the non-governmental organisations in adopting sustainable business practices.

The findings of the study are on par with the available warranted knowledge. The study found that there is a significant impact of SSCI on the EP of a firm, and also there is a significant moderation impact of external pressure in adopting SSCI in enhancing the EP of a firm. The novelty in the study is identifying and validating the external pressure exerted by non-governmental organisations, which was proved by the data collected and analysed. For the bridging of the theoretical gap identified in the institutional theory, the researcher has utilised the stakeholder theory to clarify that all stakeholders have to be considered when considering manufacturing operations.

The theoretical significance of the study mainly revolves around extending the literature related to SSCM and bridging the gap of institutional theory with the aid of stakeholder theory, which would be an eye-opener for future researchers. The measurement items used to measure non-governmental organisational pressure (NgoP) have been further validated in this study. Further, from policy development perspective governments and non-government organisations can use the findings of the study to reform policies related to manufacturing or emerging economies and also to develop tactics in exerting pressure with the expectation of enhancing the adoption of sustainable business practised in enhancing EP as a whole. Moreover, the findings of the study can be used by managerial-level employees in devising strategies and setting a long-term vision for organisations to be sustainable businesses in the manufacturing industry.

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IMPACT OF BIG DATA ANALYTICS ON THE COMPETITIVE ADVANTAGE OF E-COMMERCE COMPANIES

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I. INTRODUCTION

There have been different benefit-drivers considered by organizations, as motives for adopting traceability tools (Enterprise Resource Planning - (ERP), Radio Frequency Identification (RFID)) as a means to achieving competitive advantage. However, in this context, the Big Data Analytics (BDA) has been least explored as a benefit-drivers for adopting traceability tools and the connection with organizations competitive advantage. Exploring this niche will enable managers and policy maker to align their benefits driver (BDA) with their organizational goals. With the rapid development of information and communication technologies, the capacity of enterprises to collect, process and analyse data is increasing, Big Data Analytics (BDA) is developing rapidly, and the world is beginning to enter the era of big data (Reddy, 2014). As a result, data is transforming from a simple object to a fundamental resource. There has been a massive increase in the use of the Internet in China, with an increase in the number of e-commerce businesses leading to fierce competition. E-commerce companies rely on the Internet to complete transactions and are uniquely positioned for data collection. However, there has been a conflict in scholars' ideas on whether or not having BDA as a benefit-driver for using traceability tools could be a source of competitive advantage and the areas of the supply chain this will impact. Hence this research focuses on two B2C e-commerce companies to explore the relationship between BDA as a benefit-driver for adopting traceability tools and organizations' competitive advantage.

II. BACKGROUND

Due to the popularity of the Internet, a significant volume of e-commerce businesses has emerged in China, and China's e-commerce businesses are entering a white-hot phase. Thus, developing BDA has become a vital focus for businesses to improve their decision-making capabilities (Ali, 2016).

In addition, other studies have highlighted six major benefit drivers for traceability tool implementation, which are to - reduce cost, enhance real-time information sharing and integration, increase supply chain visibility, increase product quality and safety, reduce inventory discrepancies, and capture the volume of data for data analytics. Each of these could either be categorised as a customer-driven or corporate-driven benefit-driver. Permala et al. (2012); Piramuthu et al. (2013); Dai and Tseng (2012) in their research highlighted some of the key benefit drivers and their impact on enhancing competitive advantage. However, Chanchaichujit, et al. (2020) pointed out that compared to the various drivers, more research is required to understand the motive of firms to implement traceability tools with the objective of generating large volume of data for analytics. Compared to other drivers, only limited studies have investigated this driver. Furthermore, in-depth investigation, preferably interview-based studies, is required to gain deeper insights within each of the benefit-drivers so that sub-dimensions can be better understood. For instance, in the case of cost reduction as a driver, there are multiple opportunities to reduce cost from traceability tool implementation such as labour costs, purchasing costs, inventory cost, and cost of defects among others. Similarly, sub-dimensions of other benefit-drivers could be understood. In the case of generating large volume of data, future research could explore the common data generation points and its significance, such as data generated from warehouse and data during transportation/transit.

This formed the motivation of this study which seeks to address this gap in the literature through a qualitative research process. The aim of this research is to understand BDA (as the key benefit-driver) and the ways in which it enhances competitive advantage.

The research question is - How does adopting BDA (as a benefit-driver) impact on organization's competitive advantage?

The answers to the above questions would be useful for practitioners and policymakers to understand the opportunities afforded by traceability tools in their supply chains. For instance, different organizations will have different motives to

implement traceability tools. For instance, drivers for some firms will be on improving customer service while for others it could be increasing profitability. Therefore, a clear categorisation of benefit-drivers as 1) Corporate-driven and 2) Customer-driven benefit is likely to provide more impetus for firms to implement traceability tools in their supply chains in line with their organizational goals. Finally, a verifiable link between benefits and competitive advantage is important as organization may be looking to prioritise the implementation of traceability tools that gives them a specific competitive advantage through process improvement benefits.

III. METHODOLOGY

Data Sources and Sample Selection

The data used in this work are all primary data, mainly the data obtained after semi-structured interviews with heads of departments of small and medium-sized e-commerce enterprises. In this research, a sampling survey is chosen to select a partial sample for the investigation to estimate and infer the overall situation. The sample selection is based on the following requirements:

1. Small-to-medium enterprises
2. Operating conditions are healthy without capital problems
3. Firms in the same industry with similar business categories
4. Used BDA in daily operations
5. BDA as a benefit-driver for adopting traceability tools

After a comprehensive comparison based on these requirements, two similar B2C e-commerce enterprises were chosen for the purpose of this work.

Semi-structured Interview

This study adopted semi-structured interviews to collect the research data. There is no doubt that qualitative interviewing is a flexible and powerful tool (Rabionet, 2011). The use of a video-telephone interview breaks the time and space constraints and improves efficiency. During the qualitative interview, the semi-structured interview was conducted around the theme of what advantages the implementation of BDA brings to e-commerce enterprises. The interviewees for this study were 10 employees of two B2C e-commerce companies, including the logistics supervisors and the warehouse supervisor. Hence, the questions are divided into two main categories; the first category focuses on basic information, such as the number of hours worked and the job scope, to ensure that the respondent has been with the company long enough to understand their job function. The second type of question is personalised and asks respondents about the specific role of BDA in their work. Finally, the interview results were reviewed. After sorting out the text content, the meaningful content is classified and summarised, which is conducive to further analysis.

Data Analysis

Through reading the literature, this dissertation finds that the main impact of BDA on e-commerce enterprises includes production, marketing, operation, personnel, logistics, and after-sales. Therefore, when setting the interview questions, this work focused on these aspects, so as to obtain more and more in-depth data content. The findings were summarised according to the content of the data, combined with theory. This work first converts the audio of the interviews into text and evaluates the interview data using an inductive approach by filtering out the information that has strong relevance to the content of this research dissertation. This research adopts an inductive approach, selecting two similar shops for analysis and summarising the content of the text based on the interviews to analyse and draw general conclusions qualitatively. To facilitate analogy and generalization, the interview texts were categorized according to the position of the interviewees so that conclusions could be drawn more visually and obviously.

IV. FINDINGS AND ANALYSIS

This subsection details the analysis of the impact of BDA as a key benefit-driver for adopting traceability tools, and the ways in which it enhances competitive advantage. Each of the two companies are well-established in terms of annual revenue and number of employees. Company A is a retailer of women's clothing with 35 employees. The average daily order volume for this company is 1,500 units. Company B is a clothing company with 37 employees and an average daily order volume of 1,450. The interview time is expected to be 30 minutes. These organizations have identified BDA as their benefit-drivers for the implementation of traceability tools.

BDA Impact on logistics

In this section, the conversations with two logistics executives are analysed. To begin with, the effect of BDA in logistics is examined specifically in terms of classification of goods, optimisation of distribution routes and the location of warehouses.

- *"Using big data analytics, we can summarise the characteristics of different logistics companies in terms of delivery times, delivery routes, quality of delivery, including whether the clothes will be delivered on time and whether they will be damaged, and so on." (Logistics Supervisors A)*

Here it follows that small-to-medium e-commerce companies rely heavily on third-party logistics to achieve logistics delivery, and the consumers of e-commerce companies are scattered in different locations (Naunthong, 2022). Also, the quality of service varies from one delivery company to another. Thus, to achieve an optimal delivery plan, companies utilise BDA to analyse the delivery times, delivery routes, accurate and on-time delivery rates of goods, product breakage rates, and related data of multiple logistics companies to derive the characteristics of each logistics company. This facilitates e-commerce enterprises to match different logistics for consumers according to their location and product characteristics. All this, in turn, will reduce the amount of time the vehicles will spend on the road.

- *"We can get information on the addresses where all users are located, and by using BDA to process this information, we can generate visual images to help us intuitively access the number of consumers in each region." (Logistics Supervisors A)*
- *"We can... get the addresses of where all the target users are located and then, depending on the number of consumers in different regions, set up more logistics points in places with a high number of consumers... which can greatly reduce company costs." (Logistics Supervisors B)*

As science and technology continue to advance, consumers are recorded in big data, whether they are browsing the internet or making transactions. Therefore, companies use BDA to extract the Internet Protocol address (IP) of consumers and generate visual images to show clearly and intuitively where the main buying power is located. This enables e-commerce companies to set up warehouse locations, improve logistics efficiency and reduce transport costs and delivery times. Also, BDA's forecasting function improves the efficiency of e-commerce enterprises' goods allocation. BDA also makes it possible to optimize distribution methods and routes on time, avoiding the waste of human and material resources in transportation. As a result, BDA enables e-commerce companies to establish a complete logistics system, thus forming a unique management resource and improving the competitive advantage of enterprises.

BDA Impact on Warehouse

In this section, the interviews with two warehouse supervisors were analysed. It analyses in detail the function of large volumes of data for analysis generated from traceability tools in optimising inventory quantities, intelligently managing stock and staffing the warehouse.

- *"Too much product stock can take up a lot of warehouse space and squeeze out space for new incoming product, which can add significantly to inventory costs." (Warehouse Supervisors A)*
- *"BDA helps predict what product sales will be next... we can identify roughly how much product we need to export from our stock and how much product we need to stock in a period, and we can prepare in advance." (Warehouse Supervisors A)*
- *"Although product sales can change from year to year... we can effectively optimize stock quantities in advance based on this information as long as we have a rough volume forecast." (Warehouse Supervisors B)*

Inventory backlogs cause high inventory costs and prevent flexible allocation of business resources. Companies can use BDA to analyse historical inventory, which includes product names and historical quantities out of stock. This enables the company to forecast future demand based on historical data to identify the approximate future stock turnover cycle and the demand within a stock turnover cycle. Under inventory quota management, a dynamic inventory model is established to reduce inventory costs by arranging timely replenishment of materials when the inventory does not meet the consumption of a future inventory turnover cycle.

- *“The use of big data analysis technology can analyse the future inventory situation, and then combined with the specific storage of different clothing, it can be intelligent clothing storage methods and space division, to improve the quality of storage of goods and storage space division efficiency, specifically to the practical application we can put the frequent in and out of the warehouse materials placed in the location near the entrance and exit of the warehouse to improve the efficiency of the operation.” (Warehouse Supervisors B)*
- *“We can based on BDA, combine different clothing sizes, styles, fabrics, special storage needs and so on to deal with the storage of products, including the selection of proper storage method and planning for suitable storage locations.” (Warehouse Supervisors A)*
- *“This way, we can make more value out of the limited storage space, and at the same time, reasonable inventory management can help us to quickly move out of and into the warehouse and process orders from customers more quickly.” (Warehouse Supervisors A)*

For small-to-medium sized e-commerce companies, efficient inventory management helps to improve efficiency (Nandan and Choubey, 2019). According to these responses, e-commerce enterprises rely on BDA to forecast trends in the composition and quantity of future warehouse material types. On this basis, standardised storage space and reasonable storage partitioning are developed to improve space utilisation, taking into account the size specifications and operational requirements of each type of material. Secondly, enterprises can use BDA to analyse the frequency of incoming and outgoing products, adjust the distribution of warehouse space on time, and place materials that are frequently in and out of the warehouse in locations close to the warehouse entrances and exits to improve operational efficiency.

- *“The company can use big data analysis technology to allocate personnel to various positions, and at the same time, through the analysis of past data, to develop a reasonable personnel performance appraisal, from which a reasonable management of warehouse department employees can be carried out.” (Warehouse Supervisors A)*
- *“We can use BDA to analyse the historical data of the warehouse in and out of the warehouse, accurately analyse the peak period of in and out of the warehouse in calendar months and even calendar days; with this data, we can arrange the staff to work flexibly in advance.” (Warehouse Supervisors B)*
- *“When the peak season is reached, it is necessary to recruit in advance to avoid a situation where orders are huge and staff are overloaded, some employees can be arranged in advance to carry out other work, for different positions and even other departments of the company staff to share the pressure.” (Warehouse Supervisors B)*

The ability of an organization to effectively deploy technology and talent to capture, store and analyse data to generate insights is an essential organizational capability (Rialti et al., 2019). The company uses BDA to carry out a comprehensive analysis of the warehouse’s business and manual workload, and to clarify the number of personnel and job responsibilities for each position in relation to its actual business volume. Secondly, enterprises also use BDA to analyse the historical data of warehouses in and out, and analyse the peak period of in and out each month of the calendar year, to predict the peak period of arrival and delivery of goods in the future and make arrangements for personnel and preparation for in and out in advance. To conclude, due to the large variety of products and the large consumer base of e-commerce companies, companies sometimes face severe problems with product backlogs, which are not conducive to inventory management and the circulation of funds in e-commerce companies. Companies use BDA to monitor the stock levels of individual products and thus identify the sales trends of their products. In this way, BDA can optimize a company’s stock levels, reduce inventory costs and obtain efficient space resources. This reduces the waste of financial resources of the enterprise and increases the turnover of funds. Secondly, BDA facilitates e-commerce enterprises to reasonably plan their goods’ storage location and improve their space resources’ utilisation. Finally, BDA assists e-commerce enterprises in allocating human resources scientifically and reasonably, thus enabling them to obtain efficient management resources.

V. CONCLUSION

The result has presented multiple opportunities that could be derived from the analysis of large data derived from traceability tools. Here are some of the inferences from the interviews – The BDA of the data resources provided by traceability tools can

- *Be a unique data resource for companies to help them achieve highly accurate targeting of consumers*
- *Help companies understand market trends in a timely manner and to make scientific decisions and allocate other resources rationally to improve their competitive edge*
- *Provide decision-makers with insights and improve the quality of decision-making by analysing data resources and creating a competitive advantage for e-commerce managers (Kamilaris et al., 2017)*
- *Provide an essential competitive advantage as a vital data resource for enterprises*
- *Apparent consumer demand and a precise market positioning can effectively help companies to develop their products, which not only reduces their investment risk and, but also improves their R&D efficiency*
- *Data resources can help e-commerce businesses to conduct precision marketing, enabling them to push personalised marketing messages based on the characteristics of different consumer groups*
- *Companies rely on the data resources provided by BDA and adjust the strategic direction of the company in conjunction with the long-term growth strategy of the company, thus significantly improving the scientific decision-making of the company*
- *Help e-commerce companies fully grasp consumer preferences and provide real-time information data to determine the direction of product marketing and research and development*
- *Can be used to discover information about product mixes that are not easy to find it also helps e-commerce companies discover the characteristics of their employees so that they will be able to adjust their company's human resources and improve the efficiency of their entire operations*
- *Likewise, BDA facilitates the optimisation of product delivery methods and routes, thereby reducing waste in transport and increasing delivery efficiency. Hence encouraging environmental sustainability through the reduction in carbon emissions/ footprint*

These findings would be useful for practitioners and policymakers to understand the opportunities afforded by traceability tools implementation in their supply chains. It is evident that BDA as a motive (benefit driver) for implementing traceability tools can satisfy both the Corporate driven and Customer driven goals of e-commerce organizations. Therefore, organizations can align the use of these technologies to their goals. Finally, it is evident that BDA as a benefit driver is a source of competitive advantage. It encourages an organization to prioritize traceability tools to achieve specific competitive advantage through process improvement benefits.

VI. Future Research Direction

This work has explored how traceable tools could be a source of big data and when analysed appropriately could enhance competitive advantage. The focus of the interview was logistics and warehousing aspects of the supply chain. It is suggested that for future research more in-depth investigation, preferably, on other sectors of the supply chain such as procurement, operations etc should be carried out. This will expound on the existing knowledge to present the impact of BDA as a benefit driver on the various parts or the whole supply chain.

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DIMENSIONS OF DYNAMIC RESILIENCE CAPABILITIES TO SUPPLY CHAIN DISRUPTIONS IN THE IRISH FOOD INDUSTRY

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Introduction

Supply chain disruptions caused by systemic shocks, such as Brexit, COVID-19, and the Russia-Ukraine War, have made resilience a priority for companies with global supply chains. Businesses must build SCRM competencies to manage global SC networks (Hohenstein, 2022), and these capabilities must be adjusted according to the network's interactions and interconnectedness (Wiengarten et al., 2023). Similarly, strategic management scholars argue that in times of uncertainty, firms must develop dynamic capabilities (DC) to sense threats, seize opportunities, and reconfigure resources for competitive advantage (Teece, 2007; Teece et al., 1997). Dynamic capabilities theory (DCT) focuses on continuous organisational change to adapt to the environment (Easterby-Smith et al., 2009). Firms in dynamic and unpredictable environments must develop DC to create, extend, and modify their operational capabilities to alter their current positions and strategic paths (Helfat et al., 2007). Thus, the DCT can be used to understand SCRES capabilities in the context of disruptions. Despite the recent increase in articles on DC and SCRES, much scope remains for further exploration of the use of DCT as a theoretical lens in SCRES studies. For example, distinctions between DC and operational capabilities need clarity on how they complement each other and what specific DC routines are critical in various disruption phases. In contributing to this further work, this study's aim is twofold: First, to distinguish between DC and operational capabilities to elaborate on dynamic resilience capabilities (DRC) theory, and second, to explore a firm's DRC dimensions and how they manifest when mitigating supply chain disruptions. Therefore, we formulate the following research question to achieve this aim.

RQ: How do Irish firms exhibit dynamic resilience capabilities to supply chain disruptions in the food industry, and what are the dimensions of these capabilities?

Literature Review

Supply Chain Resilience (SCRES) Capabilities

SCRES capabilities are bundles of practices or routines through which supply chains effectively manage disruptions (Dabhilkar et al., 2016). The SCRES literature proposes various capabilities for different disruptive events classified into three phases of disruptions: before, during, and after disruptions, as well as grounded in proactive, concurrent, and reactive strategies to explain their constituents' elements and practices (Ali et al., 2017; Chowdhury and Quaddus, 2016). However, this hierarchal conceptualisation of SCRES capabilities is inconsistently applied, and hence, the extant literature is fragmented and littered with different terminologies (Ali et al., 2017; Hohenstein et al., 2015). To elaborate on SCRES capabilities, we consider a broader view of SCRES and define it as the ability to prepare, adapt, respond, recover, learn, and grow from disturbances (Ponomarev and Holcomb, 2009; Scholten et al., 2019). This definition implies that several capabilities are required to build resilience during various phases of disruption. Examples include readiness, preparedness, and anticipation capabilities in the pre-disruption phase. Similarly, adaptation or responsive capabilities during the disruption phase and recovery, learning and growth capabilities in the post-disruption phase. These capabilities are supported by several SCRES elements (e.g. visibility) and managerial practices (e.g. information sharing) in their respective phases, as discussed in the literature. Hence, the different SCRES capabilities at various phases of disruptions are high-order capabilities supported by low-order operational capabilities (Sawyer and Harrison, 2022). Furthermore, these capabilities are dynamic capabilities (DC) that enable firms to cope with disruptions and improve the resilience of supply chains (Hendry et al., 2019). Consequently, SCRES capabilities are deemed essential for the success of firms and supply chains.

Dynamic Capabilities Theory (DCT)

DCT presents a theory of firm and firm-level competitive advantage under conditions characterised by deep uncertainty (Teece, 2014) and offers a promising way to explain how organisations adapt to such conditions (O'Reilly and Tushman, 2008). In a dynamic environment, the firm avails from its DC by altering its initial position and strategic path (Zollo and Winter, 2002). The benefits of DC depend not only on the efficacy of the supporting processes and practices but also on contextual activation. Notably, the DC “fit” with the firm’s external and internal environments is critical. It determines their usefulness as a mechanism for adapting to, exploiting, and creating changes in business climate (Helfat et al., 2007). A critical debate in the DC literature is the distinction between dynamic and operational (or ordinary) capabilities (Helfat and Winter, 2011; Schriber and Löwstedt, 2020). Although both capabilities are a collection of routines, dynamic and operational capabilities differ in their purpose and intended outcomes (Helfat and Winter, 2011). Operational capabilities enable a firm to function in the present and focus on doing things right (Teece, 2014; Winter, 2003). By contrast, dynamic capabilities allow firms to change their operations (Eisenhardt and Martin, 2000). DC encompasses managerial practices and organisational processes that ensure learning, integration, reconfiguration, and transformation as the market changes (Helfat et al., 2007; O'Reilly and Tushman, 2008). Therefore, a firm’s DC can impact its performance, competitive advantage, position, and strategic path (Helfat and Peteraf, 2009; Pavlou and El Sawy, 2011) by allowing it to engage in continuous or semi-continuous sensing, seizing, and transformation to stay consistent with the environment (Teece, 2007). DC are built through investments in discovery, knowledge generation, and learning (Teece, 2019), and are a source of sustained competitive advantage (Eisenhardt and Martin, 2000). Unlike ordinary capabilities, DC cannot be bought in the market, which explains why intangible assets such as a firm’s collective knowledge and capabilities are scarce and difficult to imitate (Teece, 2017).

SCRES Capabilities and Dynamic Capabilities: Conceptualising Dynamic Resilience Capabilities

Drawing on the theoretical foundations of SCRES capabilities and DCT, we contend that both concepts are similar concerning uncertainty and the rapidly changing business environment. Indeed, its potential value in SCRES studies has demonstrated the application of DCT in different contexts. However, one source of ambiguity in using the DCT in SCRES studies is the lack of distinction between operational and dynamic capabilities. Based on DC theorists, dynamic capability is a high-level competence that alters operational capabilities to sustain a competitive advantage (Helfat et al., 2007). Extending this logic to the SCRES context, a firm’s high-level SCRES capability (e.g. ability to respond) is supported by operational capabilities (e.g. collaboration) and managerial practices (e.g. information sharing) to alter its resources to sustain business continuity and competitiveness. However, this rationale has been inconsistently applied in SCRES studies. Therefore, a clear distinction in the use of the DCT is required to facilitate better theory building and testing in SCRES studies.

Consequently, we propose a synthesis of both concepts to elaborate the theory of Dynamic Resilience Capabilities (DRC). Specifically, we differentiate between high-order and low-order capabilities based on prior SCRES studies that distinguish between dynamic and operational capabilities (Dubey et al., 2023), and classify DC as high-order capabilities (Sawyer and Harrison, 2022). In doing so, we adopt Eisenhardt and Martin’s (2000, p.1107) view that “dynamic capabilities actually consist of identifiable and specific routines” to develop DRC theory. We identify high-order SCRES capabilities and their elements and practices based on Hendry et al. (2019) and Sawyer and Harrison (2022) and use Ali et al.’s (2017) five core SCRES capabilities— anticipating, adapting, responding, recovering, and learning —as the theoretical basis for our theory of DRC. The five SCRES capabilities integrate SCRES capabilities, elements, and managerial practices, and capture the hierarchical view of DC to differentiate between high-order and low-order capabilities. We look for DC attributes that resemble the five SCRES capabilities. Teece et al. (1997) proposed three managerial processes for DCT: coordination/ integration, learning, and reconfiguring. These processes enable sensing, seizing, and reconfiguring resources in a changing environment, which can be seen as asset “orchestration” (Teece, 2007). Similarly, a firm’s adaptive, absorptive, and coordinating capabilities are distinctive DC features that influence its performance (Pavlou and El Sawy, 2011). Also, learning is essential for the development of DC (Eisenhardt and Martin, 2000). As such, DCs are established through intentional actions (Zollo and Winter, 2002), allowing firms to recognise opportunities rapidly, capitalise on them more efficiently, and facilitate the transformation processes necessary to remain competitive (Day and Schoemaker, 2016). Therefore, the higher-level DC processes of sensing, adapting, coordinating, reconfiguring, and learning are enabled by lower-level DC capabilities. By applying the logic of high-order DC capabilities to SCRES capabilities, we argue that the five DRC are high-order capabilities that depend on operational capabilities for anticipation, adaptation, response, recovery, learning from disturbances, and evolving business conditions. By leveraging these capabilities, firms can sense, adapt, coordinate, reconfigure, and learn how to endure and prosper in the face of disruptions and maintain their competitive edge in various resilience phases.

Contextualising DRC in the Food Industry

There has been growing concern that the global food supply chain (FSC) must be more resilient in its food production and distribution to withstand various risks—pandemic, economic, natural disaster, intentional, or unintentional. Indeed, the FSC resilience literature includes various studies examining capabilities and strategies to mitigate global FSC risks relative to food quality, safety, and security. Moreover, Brexit emphasised the need to build local FSC resilience to constitutional changes (Hendry et al., 2019). However, studies on FSC resilience are still in their early stages, and lack frameworks and theories (Umar et al., 2017). Recent studies have proposed conceptual or theoretical frameworks based on the resilience phases of readiness, response, recovery, and adaptation (Hendry et al., 2019) and rooted in DCT (Ali et al., 2022) to address some limitations. This study seeks to build upon recent work on FSC resilience to elaborate on the DRC theory in the Irish food industry in the three phases of pre-, during-, and after-disruptions by examining firms' DRC dimensions.

Research Methodology

We conducted an exploratory multiple-case study of the Irish food industry, focusing on supply chain disruptions. This was done to identify resilience practices that build SCRES capabilities to manage disruptions in the Irish food industry. Therefore, 12 local and global companies were chosen to analyse their supply chain challenges and resilience practices. These companies are important for understanding SCRES capabilities because of their intricate supply chains and recent disruptions in the Irish FSC (e.g. Brexit). Cases of different sizes, product varieties, and customer/supplier numbers were chosen to gain insights from multiple FSC disruption perspectives. This study used 15 semi-structured interviews with 12 Irish food and drink industry companies (Jan–Aug 2018). Interviewees were chosen based on their work experience, knowledge of supply chain risks, and expertise in internal and external processes. Data analysis used a hybrid thematic analysis, combining inductive and deductive a priori codes (Fereday and Muir-Cochrane, 2006). The analysis began by condensing transcripts into relevant sentences, quotes, and paragraphs before engaging in the first- and second-cycle coding processes (Miles et al., 2014; Saldana, 2016). Data-driven codes and theoretical categories are linked to the five SCRES capabilities through abduction logic, which adapts general theory to contextual specifics (Ketokivi and Choi, 2014).

Findings and Discussion

This section examines the qualitative study based on DCT to answer the research question on a firm's DRC to supply chain disruptions. Table 1 illustrates an excerpt of the coding process, using multiple reasons for inductive, deductive, and abductive logic.

Resilience Phases/ Capability (Dynamic Capability Routines)	Data Condensation (Quote/Example)	1 st Cycle Coding (Descriptive & Process Coding): Sorting SCRES Practices	2 nd Cycle Coding (Pattern Coding): Categorising SCRES Practices	Link to SCRES Elements (Based on Literature)
Pre-disruption/Ability to Anticipate (Sensing Routines)	We have what we call supplier partner managers, where our larger suppliers had somebody within their supply chain dedicated to us and treated as part of our team. They will have a good relationship and work closely with us to understand what's going on in both of our supply chains. Where we say if we were one business, what would we do differently, and what would we look to improve upon? So, then we would combine our supply chain knowledge. We will always look together at the end to end [supply chain], and how can we make improvements, and where are our risks (Case I).	Knowledge sharing with partners	Education and Training	Pre-disruption Knowledge Management
	Those plans [forecasting plans] are also shared with key suppliers, not all suppliers but with the key suppliers. Whether it would be grain, glass or water, all those key elements or requirements, are formally shared and signed off with the suppliers in terms of ability and capacity to meet requirements (Case L).	Sharing information with key suppliers	Information Sharing	Visibility
	The recent changes by the Irish government and the Met service, to issue weather warnings gives us an increased awareness level earlier on. We can now see what's happening, so we see the severity of it and plan (Case C).	Increasing weather awareness level, Continuity planning, Warning strategies	Sensing and Interpreting Events	Situation Awareness
During-disruption/ Ability to Adapt (Adaptive Routines)	We have some contingency in offering some people, additional shifts without that falling into overtime. We have flexibility around our staff and every contract that is issued states specifically that flexibility is part of the deal. So, we bring people in for additional shifts (Case D, D1).	Flexible staff, additional shifts	Flexible labour	Increasing Flexibility
	Quality is so important to company B, so it depends on what the level of the interruption and the impact. We look for alternative sources ... can we change manufacturing around ... For example [if] there is a quality issue, and we have to pull certain products, what happens with that for continuity, we check an alternative supplier (Case B, B2).	Alternative sourcing, change manufacturing, an alternative supplier	Flexible supply management	
	If we are made aware that there is a storm coming and the ferries will be shut down for 24–48 hours, we may have stock sitting in a cold store beside us that needs to go through a maturation process. We will pick that product 2 or 3 days too early we will put on additional loads and ship out to the UK based cold store so that before the ferries have stopped shipping the products that our customers require will already be sitting close to their depot (Case G).	Extra stock, extra storage facility	Safety stock, Backup storage facility	Building Redundancy
During-disruption/ Ability to Respond (Coordinating Routines)	We have 120 suppliers coming in here on any given day. I would say in the region of 95% are aligned with our processes. We have what you'd call a reorder team which is centralised in our head office in Cork. They deal with suppliers and communication around any issues (Case D, D1).	Supplier alignment, Communicating with suppliers	Collaborative Relationships, Communications with Partners	Collaboration
	We can react from a planning point of view, a communication point of view pretty much within minutes, uh, hours. Where we are less agile is depending on where you get the product from, and the lead time to get it into the depots, and stores. So if we had a particular issue with Coke, I could go right, Coke enterprises in the UK, and I could probably fix it and get a supply there probably within a day or 2. If I had to go as far afield as Poland or the Czech Republic, it might take me 2 or 3 days to get it sorted, this is where the safety stocks and all those sorts of things come in, and they buy us the time to do that (Case I).	Rapid reaction time	Operational Responsiveness	Agility
Post-disruption/Ability to Recover (Reconfiguring Routines)	We have plans and back-ups for people, for technology, from an infrastructure point of view we can go remote, we can work somewhere else. If there is a big problem with the number of trucks, then that might be slightly more problematic because if you haven't got the trucks then, you can't just look around, you must go further afield. That may take longer to implement, but there are plans for all of those sorts of things; for people, technology and process, and infrastructure from trucks and shed point of view (Case I).	Formal recovery plans	Recovery Plans	Contingency Planning
Post-disruption/Ability to Learn (Learning Routines)	It's a very formal process whereby if you have a quality issue, a formal team comes together, and there would be very senior director put in charge as the owner. Below that there would be a group of functional experts, who come together to understand what happened, why it happened, how it happened, and how we can learn from it. That is a formal report, which is then presented to the board of the organisation. Key recommendations are embedded within the organisation, and learning must be adopted if there is any future issue (Case L).	Senior management involvement, multi-functional involvement, embedding learning within the organisation	Becoming a learning organisation	Post-Disruption Knowledge Management
	What you would say to them [suppliers], you're better to tell us because then we can mitigate the risk and work with you. In terms of you can keep the stock, we can push that out for a couple of weeks, or we can give you the ingredients. So, we do share with them because I'd say that they're just the other side of the hand like they're experiencing the same issues as us. So, we do talk to them. Plus, a lot of times when this is happening it costs them money, so what you're trying to do is they're very interested in not having to lose money, going forward either. So, it's very much in their interest as well (Case B, B2).	Relational competence	Inter-organisational relationships	Building Social Capital

Table 1: The Excerpt of the Coding Process

Dimensions of Firm Dynamic Resilience Capabilities

Pre-disruption Phase: Ability to Anticipate as Sensing Routines

The findings indicate that Irish firms in the food industry are always alert, seeking information and knowledge to reduce or eliminate the threat of FSC disruptions. To this end, firms engage in various practices within and across their supply chains to identify potential problems and prepare for unexpected interruptions. The findings highlight that the SCRES elements of pre-disruption knowledge management, visibility, situational awareness, and robustness are essential for a firm's ability to anticipate disruptions in the Irish FSC. Together, these elements provide crucial insights into a firm's readiness to anticipate disturbances. They increase sensing capabilities and proactiveness, highlighting their weaknesses and strengths in identifying potential disruptions and monitoring critical events to build resilience capabilities. Therefore, the findings support the idea that the ability to anticipate resembles the characteristics of sensing routines discussed in the DCT literature. Sensing capabilities in dynamic environments relate to scanning, creation, learning, and interpreting activities, both internally and externally (Teece, 2007). Firms must continually scan, search, and explore markets to identify and shape their opportunities and threats. Sensing capability is the ability to spot, interpret, and pursue environmental opportunities (Pavlou and El Sawy, 2011, pp. 243–244). Consequently, the following research proposition (RP) is proposed based on these findings:

RP1: A firm's ability to anticipate disruptions through visibility, robustness, pre-disruption knowledge management, and situational awareness practices demonstrates its dynamic sensing routines by identifying threats and opportunities. Such practices enhance DRC by increasing a firm's readiness during the pre-disruption phase.

During-disruption Phase: Ability to Adapt as Adaptive Routines

The findings indicate that increasing flexibility and building redundancy are essential SCRES elements that foster a firm's adaptive capabilities in the Irish food industry. Adapting to disruptions is vital to a firm's overall responsiveness. It allows firms to manage and adjust their resources accordingly based on the severity of the disturbances. This ability manifests itself in the Irish food industry through various resilience practices, ranging from merely having additional inventory to more costly methods, such as extra capacities. As discussed in the extant literature, these practices are grouped into broader categories and linked to conceptual constructs (i.e. flexibility and redundancy). Furthermore, the findings indicate that the dimensions of a firm's ability to adapt, as highlighted by the participants, share attributes with dynamic adaptive routines. For example, firms with high levels of adaptive capability often display dynamic capabilities in a volatile environment (Teece et al., 1997) through their strategic flexibility of resources and the positioning of these resources, along with firm structure and the rapidly changing needs of the business environment (O'Reilly and Tushman, 2008). Similarly, building redundancies in excess capacity to respond to disruptions resembles mobilising resources to address needs and opportunities to capture value (Teece, 2014). The ability to adapt explains how firms, during disruptions, manage and adjust critical supply chain resources to absorb and cope with disturbances, which can alter their current paths and strategic positions. Thus, the following research proposition is formulated:

RP2: A firm's ability to adapt to disruptions by building flexibility and redundant practices demonstrates its dynamic adaptive routines by adapting to environmental changes. Such practices enhance the DRC by increasing a firm's responsiveness during disruptions.

During-disruption Phase: Ability to Respond as Coordinating Routines

The findings support collaboration and agility, as discussed in extant SCRES literature, as critical elements of a firm's resilience capability. These elements are vital to a firm's ability to respond to disruptions. In the Irish food industry context, the ability to respond manifests through various resilience practices, ranging from collaborative relationships and information sharing to rapid management decision-making. These practices are classified into theoretical categories and are further linked to the constructs of collaboration and agility. The findings suggest that collaboration and agility are antecedents of a firm's ability to respond to disruptions. Furthermore, the findings support the idea that the dimensions of the ability to respond share commonalities with dynamic coordinating activities, as discussed in DCT literature. For example, in a dynamic environment, firms which can demonstrate timely responsiveness to coordinate and deploy internal and external

competencies are competitive in the global market (Teece et al., 1997). In times of uncertainty, operational capabilities require efficient coordination of tasks and resources and synchronisation of activities to alter a firm's resource base (Helfat and Peteraf, 2003). Also, coordinating capability enables firms to orchestrate and deploy tasks, resources, and activities (Pavlou and El Sawy, 2011) and combine various resources in an entrepreneurial fashion (Teece, 2014). This capability can alter a firm's current path and strategic position by seizing opportunities earlier than competitors. Therefore, the following research proposition is proposed:

RP3: A firm's ability to respond to disruptions by building agility and collaborative practices demonstrates its dynamic coordination of routines by coordinating tasks and synchronising activities during disruptions. Such practices enhance the DRC by increasing a firm's responsiveness to disruptive events.

Post-disruption Phase: Ability to Recover (Reconfiguring Routines)

The ability to recover from disruptions manifests itself in the Irish food industry through several resilience practices. These pertain to operational review, recovery plans, and scenario analysis categories. A firm's ability to recover is an essential reactive capability in the aftershock of a disruptive event that is required to restore or return to normal operations. The findings indicate that building contingency plans that can be activated post-disruption is vital to a firm's overall recovery. The findings also indicate that resilience practices related to a firm's ability to recover from disruption share similar characteristics with dynamic reconfiguring routines. For example, firms with DC can maintain competitiveness by enhancing, combining, protecting, and, where necessary, reconfiguring their intangible and tangible assets (Teece, 2007). In a dynamic environment, the ability to recombine and reconfigure assets is critical to sustained growth, along with existing capabilities and organisational structure, as changes occur (O'Reilly and Tushman, 2008; Ambrosini et al., 2009). DC, therefore, administers changes to operational capabilities by reconfiguring them to the changing environment. In the aftermath of a supply chain disruption, this capability defines how a firm can restore its function and return to a normal or new state, which can alter its current position and strategic path in the market. Therefore, the following research proposition is proposed:

RP4: A firm's ability to recover after disruption by activating contingency practices demonstrates its dynamic reconfiguration of routines by reconfiguring tangible and intangible assets and resources after a disruption. Such practices enhance the DRC by increasing a firm's recovery from disruptive events.

Post-disruption Phase: Ability to Learn (Learning Routines)

The findings suggest that post-disruption knowledge management and building social capital are essential SCRES elements which cultivate a firm's learning capabilities in the Irish food industry. These capabilities are reinforced by an array of resilience practices that allow firms to improve their future performance based on their experience, growth, and competitiveness within the market. Indeed, resilience practices such as education and training, post-disruption feedback, and leveraging co-creation processes share traits similar to those in dynamic learning routines. For example, learning is at the heart of dynamic capabilities and plays a significant role in their creation and development (Teece et al., 1997; Eisenhardt and Martin, 2000). Therefore, organisational learning is a source of DC formed by the co-evolution of learning mechanisms (Eisenhardt and Martin, 2000; Zollo and Winter, 2002). The ability to learn defines how firms can seek growth by becoming a learning organisation through lessons learned and building social capital after a supply chain disruption. Resilience practices enforcing learning capabilities can help create, extend, and modify a firm's resource base to respond better to the changing external environment and seize opportunities, thus altering its current position and strategic path. Therefore, the following research proposition is developed:

RP5: A firm's ability to learn from disruption through post-disruption knowledge management and building social capital practices demonstrates its dynamic learning routines through learning from success and failure. Such practices enhance the DRC by increasing a firm's learning mechanisms from disruptive events.

Figure 1 illustrates a framework for a firm's DRC based on the findings and literature. It shows five formative dimensions of a firm's DRC for managing disruptions in different phases.

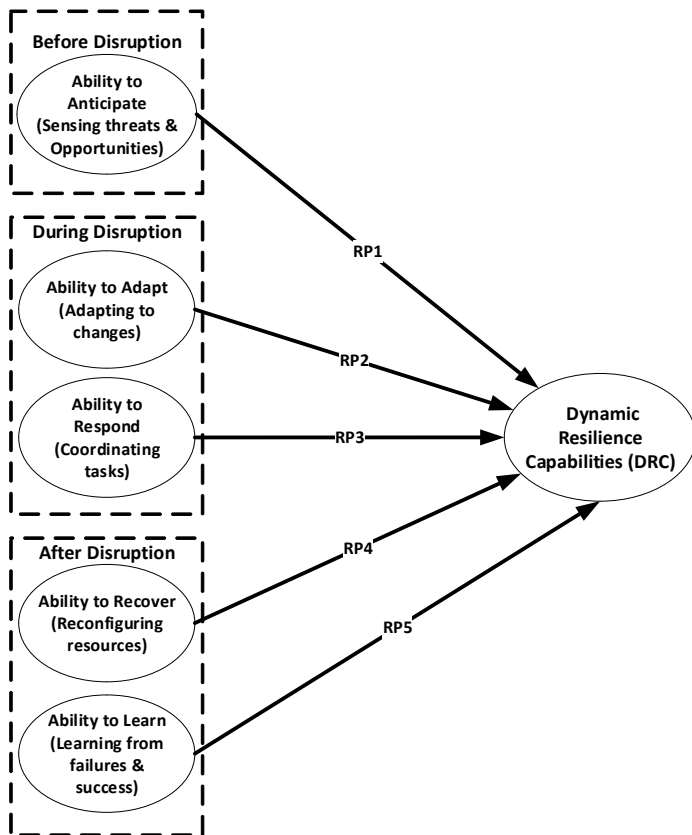


Figure 1: A Firm's DRC Framework for Mitigating Disruptions

Conclusion and Implications

In situations of uncertainty and a rapidly changing business environment, firms need to establish resilience practices to survive and thrive and their DC to alter these competencies. This study provides a theoretical fusion of these two domains to identify compatible DRC for supply chain disruptions. A firm's DRC explains how it senses threats and opportunities; adapts to changes; coordinates tasks; reconfigures resources; and learns routines to anticipate, adapt, respond, recover, and learn from disruptive events. This enhances the knowledge to advance theory building and testing using the DCT in SCRES studies. Subsequently, this study's research implications relate to classifying high-order SCRES capabilities into their respective DC routines, the distinctions between DC and operational capabilities, and how they complement each other in mitigating disruptions. These distinctions are often blurred in the current literature, providing a better theory-building platform for using DCT in SCRES studies. In addition, it lays the foundation for future studies to analyse further the relevance of each DRC dimension in different applications and contexts beyond the food industry.

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LEAN SIX SIGMA FRAMEWORK: ANTECEDENT FOR FAST-MOVING CONSUMER GOODS SUSTAINABLE SUPPLY CHAIN PERFORMANCE

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1. Introduction

Sustainable supply chain operation is critical towards achieving economic growth and operational excellency. There is increasing pressure from regulators, society, and other stakeholders towards optimising sustainability efforts (Ganjavi and Fazlollahtabar, 2021). There is an extensive focus from organisations towards improving the sustainable performance of their supply chain operations (Antosz, 2022). Sustainability will enable supply chains to meet the present requirements, without compromising future needs (Ganjavi and Fazlollahtabar, 2021). Multiple innovative strategies are implemented to enhance sustainability performance, including lean six sigma (LSS) (Caiado et al., 2018). The fast-moving consumer goods (FMCG) sector is a rapidly growing industry across the world, adapting to the latest trends, responding to customers' requirements, and increasing operational resiliency (Ahmad et al., 2022). Several complexities arose during the past couple of years in the FMCG sector in Oman (Oman Observer, 2022). FMCG supply chains are severely impacted by recent trends and transformations, including political crises, natural disasters, and economic downturns (Chopra et al., 2022; Parmar and Desai, 2020). Industry practitioners are encouraged towards continuous improvement and innovation of operations through implementing various strategies, to achieve operational excellence. Indicating that substantial efforts are required to identify and address potential challenges to boost FMCG SSCP in Oman.

2. Literature Review

1. Linkages Between Lean Six Sigma and Sustainable Development

Application of the LSS technique enables the attainment of quality effectiveness in operations (Haerizadeh, 2018). LSS is defined as “a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results” (Snee, 2010). Lean focuses on the elimination of waste and the improvement of processes and flows (Haerzideh, 2019; Singh and Rath, 2018). Whereas Six Sigma focuses on reducing operational variations and boosting quality performance (Haerzideh, 2019). LSS enhances operational excellence through the innovative integration of Lean strategies and Six Sigma models, resulting in boosting the levels of efficiency and effectiveness in operations (Parmar and Desai, 2020). LSS is rapidly evolving into an effective leadership improvement methodology, providing sustainable tools to empower leaders into implementing and managing change in organisations' operations (Antozs et al., 2022).

For decades, sustainable development has been described as meeting the requirements of the present without compromising the development of future generations (WCED, 1987). Sustainability aims to provide environmental, economic, and social balance. Sustainability entails implementing strategic actions to consider solving serious environmental, economic, and societal challenges (Parmar and Desai, 2020). Prior studies argued that LSS supports the sustainability of an organisation by eliminating waste and controlling the environmental impacts caused by numerous activities in an organisation (Chugani et al., 2017; de Freitas and Costa, 2017). Such as energy efficiency, lead times, and people management (Chugani et al., 2017). Which results in the sustainable development of an organisation (Cherrafi et al., 2017).

2. The Fast-Moving Consumer Goods Supply Chain

The FMCG supply chain significantly contributes to global economic growth (Al Junaidi and Ankrah, 2014). Although Oman's economy depends on the Oil and Gas sector, the FMCG sector plays a major role towards the attainment of the country's visions 2040 and 2050 of diversifying the economic resources (Oman Observer, 2022). The FMCG supply chain is significantly complex, with a high level of competitiveness, and a diversified distribution network, which requires continuous innovation and improvement in its networks. Numerous factors impact the performance of the FMCG supply chain, these

include warehouse management, inventory management, relationship management, and technology implementation, amongst others (Chopra, et al., 2022). The complexity of the FMCG supply chain is enhanced by the fast movement of finished goods within the network, thus increasing challenges related to the supply chain's consistency, efficiency, and resilience (Talukder et al., 2021). Further developments are essential to improve the FMCG SSCP (Tanudiharjo et al., 2021).

The existing complexities in the current supply chain further increase operational complications and challenges (Ahmad et al., 2022; Chopra et al., 2022). For instance, the sustainable management of goods availability, controlling counterfeit products, infrastructure availability and readiness, and optimisation of operations are major concerns in FMCG (Tanudiharjo et al., 2021). These challenges indicate the urgent need of integrating existing supply chain management strategies with advanced solutions, such as LSS, blockchain, and industry 4.0 and 5.0 (Yuan and Xue, 2023), to achieve operational excellence, competitive advantage and improved SSCP (Antony et al., 2020).

3. Application of Lean Six Sigma on Fast-Moving Consumer Goods Supply Chain

It is established that LSS can significantly contribute to optimising the efficiency and effectiveness of FMCG manufacturing operations and distribution networks. There are several benefits to the application of LSS in the manufacturing sector. These benefits include improved financial performance, enhanced customer satisfaction, and minimising costs related to poor quality (Antony et al., 2020). The application of LSS is also linked with reduced inventory, lead time, and cycle time, which leads to enhanced operational quality and performance (Antony et al., 2020; Haddad, 2019). It is also argued that LSS analysis can be utilised in identifying the weaknesses and strengths of a supply chain network (Chopra et al., 2022). The manufacturing industries highlighted the importance of adopting the systematic approach of LSS towards maximising operations' productivity through eliminating waste and managing supply and demand dynamics (Nader, 2022). LSS is crucial for controlling and eliminating supply chain challenges and improving operational performance (Trubetskaya et al., 2022).

4. Research Gap

Although several studies have been conducted that highlighted the key supply chain challenges facing the FMCG sector in different countries and suggested the application of LSS to improve the SSCP (Chopra et al., 2022; Ahmad et al., 2022). But there are still insufficient studies conducted in Oman or the Gulf region in general. This research intends to close this gap by identifying the contemporary challenges in the FMCG sector in Oman, to develop a LSS framework to boost SSCP. LSS is a key continuous improvement initiative, towards achieving operational excellence and competitiveness (Ahmad et al., 2022).

3. Methodology

3.1 Desk Study

A scoping study is conducted by reviewing extant literature to identify the key themes and research gaps related to the application of LSS to improve FMCG SSCP. Using Key themes and research gaps related to the application of LSS to improve SSCP in the FMCG sector across numerous countries are identified from prior studies (Al Junaidi and Ankrah, 2014; Tanudiharjo et al., 2021; Chopra et al., 2022). The literature review enables a wider observation of the implications of the implementation of LSS in the FMCG supply chain.

3.2 Empirical Data Collection

The data collection phase consists of two components, namely qualitative and quantitative data gathering. The qualitative data collection involves semi-structured interviews with the FMCG professionals in Oman. Interviews are conducted to identify the challenges impacting the FMCG SSCP in Oman and to determine the challenges and opportunities in implementing LSS towards enhancing the SSCP. The quantitative data collection involves a survey conducted with FMCG professionals in Oman to measure the key challenges facing the FMCG supply chain in Oman, to improve SSCP (Al Junaidi and Ankrah, 2014).

3. Data Analysis

The qualitative data collected from semi-structured interviews are analysed using template analysis to identify key themes

relevant to FMCG SSP. Template analysis is a type of thematic analysis that incorporates the use of a structured, hierarchical, and flexible coding system (Brooks et al., 2015). The quantitative survey data collected are analysed using AHP to rank the challenges affecting the FMCG SSCP in Oman (Piprani et al., 2021). AHP is an inclusive technique, considered to formulate a multi-criteria hierarchical system, to facilitate the decision-making process (Taherdoost, 2017; Piprani et al., 2021). The DMAIC framework is applied through the integration of each step in the study based on the findings obtained from the qualitative and quantitative data analysis, to achieve the study's main aim of proposing a practical framework for FMCG supply chain practitioners in Oman (Chopra et al., 2022).

4. Analysis, Results and Discussion

4.1 Qualitative Analysis

Template analysis established that challenges related to products' life cycles and perishability have a significant impact on the SSCP of the FMCG networks. Whereby, inadequate quality management of products' condition contributes to raising waste and defects rate, and these consequences affect purchasing power across the supply chain. In addition, customers' level of reliability towards certain products significantly affects the purchasing power in the market. Demand volatility causes further interruptions in the supply chain, creating the "domino effect". Whereby, fluctuations in demand initiate long queues and long supply lines, hence, delays and economic loss, specifically with global outsourcing of materials. Findings suggest that considering Oman's geographical location, population, and geographical spread, FMCG supply chain participants should adopt strategic approaches towards responding to the market's demand requirements. These approaches should include geographical segmentation, which is a popular strategy to efficiently serve customers with different locations and preferences. Customers' geographical spread in Oman is unique because market demand is concentrated in specific and highly populated areas in the northern part of the country such as Muscat compared to the low-populated areas in the south of Oman, such as Dhofar.

It is established that LSS plays a major role in constructing a sustainable supply chain system towards optimising operational productivity and boosting the SSCP in Oman's FMCG systems. It is suggested that innovative improvement solutions for satisfying market demand and reducing the turnover rate of customers and employees, as well as enhancing waste management and effective inventory management will significantly reduce costs, cycle time, and defects rate. Integrated solutions, such as motivating local outsourcing, instead of global outsourcing will enhance the sustainability of the FMCG supply chain in Oman by reducing lead time, disruptions, and carbon footprint, as well as promotion of in-country value.

Akin to many countries, several challenges influence the environmental performance of Oman's FMCG sector (de Freitas and Costa, 2017; Tanudiharjo et al., 2021). For instance, the complexity of the FMCG distribution network creates is linked to greenhouse gas (GHG) emissions due to transportation and accessibility, especially to rural regions. The FMCG supply chain is also associated with long lead times, which affects the sustainability of its network in Oman. For example, trucks are obligated to continue operating for long periods in queues, however, this results in sustainability losses due to the perishability of some products and non-compliance with specifications on shipping and transportation conditions.

Findings revealed that technology limitations are the major factor affecting visibility across the FMCG supply chain in Oman. Poor supply chain visibility poses a challenge to the tracking and tracing of perishable products, considering the unique requirements of certain products. For instance, dairy products require critical observation of the product's condition throughout the supply chain, cold chain, and distribution network, and this is elaborated in Oman due to the hot climatic condition. However, efforts to safeguard products' quality should consider the possible negative environmental impact of the FMCG supply chain, such as emissions caused by refrigerated trucks. This can be mitigated by implementing LSS to boost the industry's capacity in waste management to reduce the overall negative environmental impact (de Freitas and Costa, 2017). LSS can accelerate the cycle time and lead time in the FMCG supply chain, which will significantly contribute to reducing queues and waiting rates (Al Junaidi and Ankrah, 2014).

4.2 Quantitative Analysis

AHP is used to evaluate the relative impact of the 7 wastes of lean on the key pillars affecting FMCG SSCP as alternatives, consisting of overproduction (A1); queues (A2); transportation (A3); excess inventory (A4); motion (A5); overprocessing (A6); defective products (A7). These alternatives are evaluated based on their impacts on FMCG sustainability dimensions, comprising social (C1); environmental (C2); economic (C3), as illustrated in Figure 1 (Zubairu et al., 2021).

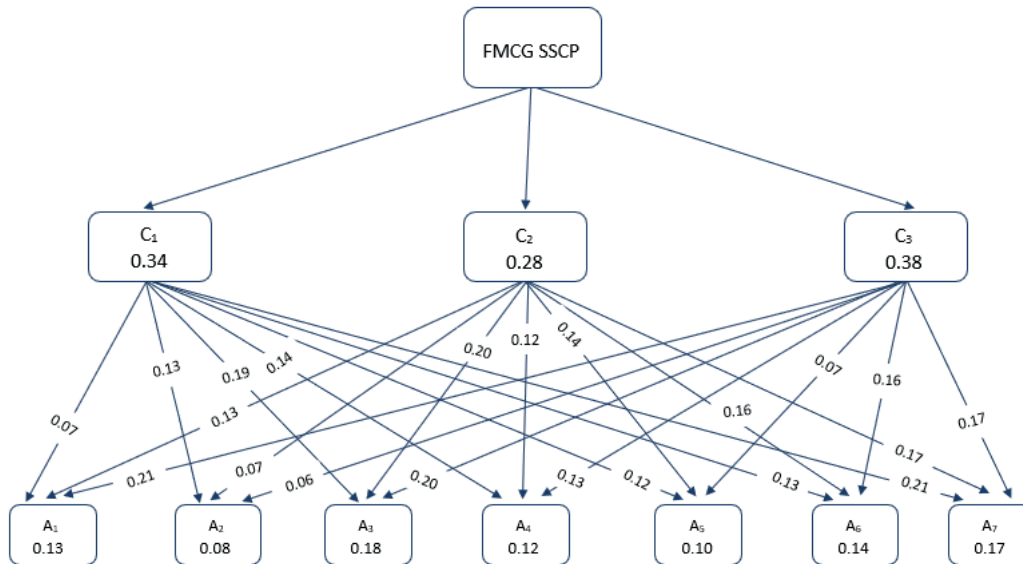


Figure 1: AHP Hierarchical Structure for FMCG SSCP

4.2.1 Effect of Sustainability on Fast-moving Consumer Goods Sustainable Supply Chain

According to de Freitas and Costa (2017), sustainability is consistently becoming one of the major aspects of industries' goals towards the continuous development of operations. To promote productivity and achieve operational excellence in Oman's FMCG supply chain, it is crucial to identify the potential impact of sustainability pillars on the FMCG network. As illustrated in Figure 1, the economic pillar (C3) has the highest influence of 38%, followed by the social pillar with an influence of 32% on FMCG SSCP. Results revealed that the environmental pillar has the lowest influence on the FMCG SSCP in Oman, weighing 28%. Although findings show that the economic and environmental dimensions have the higher weights, all three sustainability pillars have a relatively strong influence on FMCG SSCP, indicating the importance of all sustainability pillars toward improving FMCG SSCP.

4.2.2 Challenges Affecting Fast-moving Consumer Goods Sustainable Supply Chain

The results from the priority matrix presented in Figure 1 compare alternatives' weight and reveals the group ranking of sustainability challenges affecting the FMCG supply chain in Oman. This is measured relative to the degree of challenge posed by the three sustainability dimensions of social, environmental, and economic. As illustrated, transportation (A3) with a weight of 18% is considered the most critical factor affecting FMCG SSCP. The second most influential factor is defective products (A7) with 17%, followed by overprocessing (A6), and overproduction (A1), having 14%, and 13% impacts on FMCG SSCP, respectively. Results revealed excess inventory (A4), motion (A5), and queues (A2) as the least factors affecting FMCG SSCP in Oman, with an influence of 12%, 10%, and 8%, respectively.

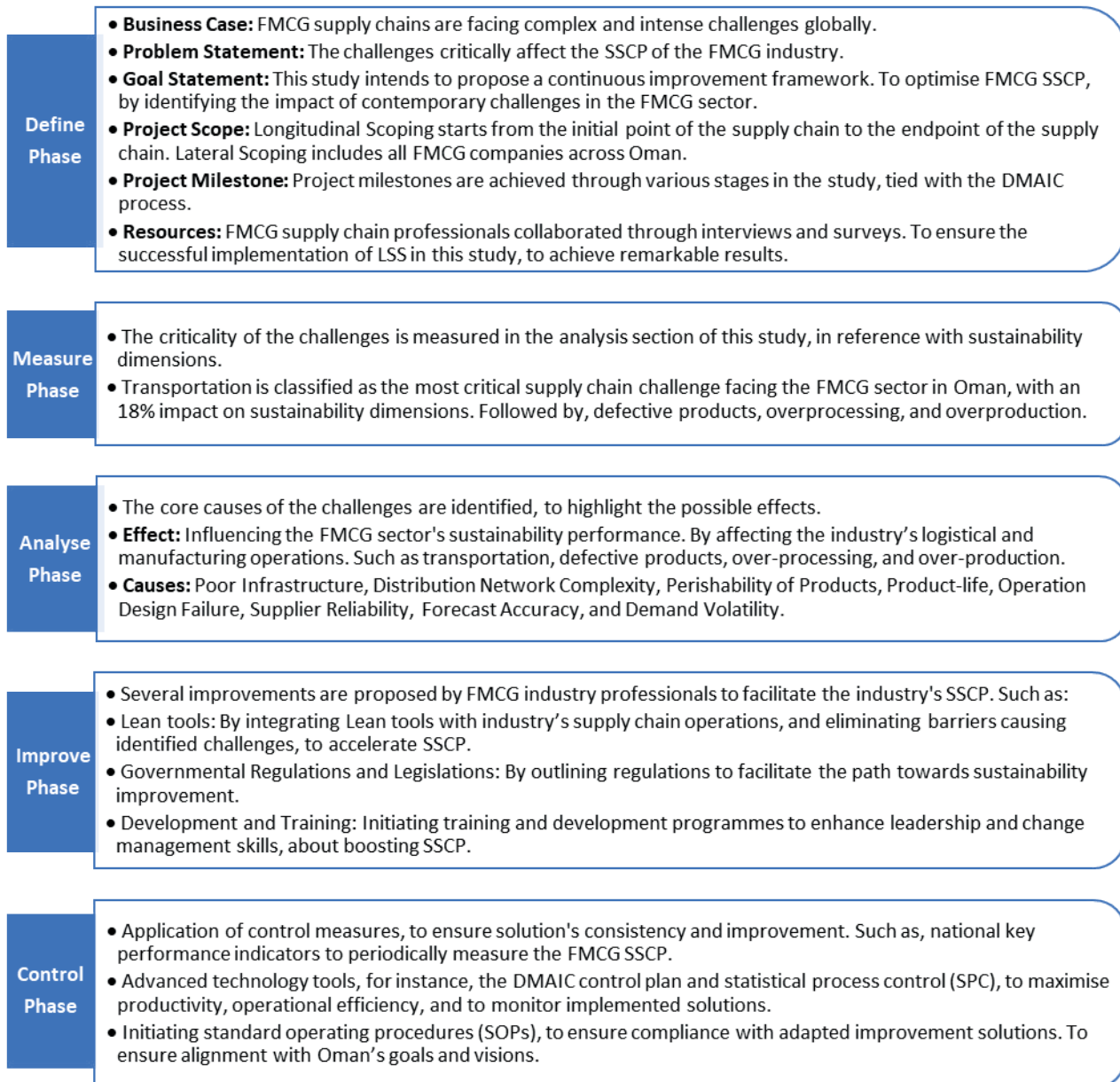


Figure 2: DMAIC Framework of FMCG SSCP

5. Conclusions, Implications, and Directions for Future Research

Akin to extant literature findings, this study revealed that the application of the LSS framework proposed can significantly enhance FMGC SSCP in Oman. AHP findings established that transportation, defective products, and overprocessing are considered the major supply chain challenges facing the FMCG SSCP in Oman. Other supply chain challenges such as overproduction, excess inventory, motion, and queues are considered minor in terms of impact on SSCP in the FMCG network. These are attributed to poor infrastructure, demand volatility, and product perishability issues, as revealed in the template analysis findings.

1. Implications of the Study

This study highlights the challenges facing FMCG SSCP in Oman. The paper established the critical role of LSS in improving the management of waste to enhance FMCG SSCP. Further, the paper suggests implementing initiatives, including LSS tools, automation solutions, and control measures to address supply chain challenges facing FMCG SSCP. The challenges affecting FMCG SSCP identified will guide practitioners in making strategic decisions. Importantly, an original LSS framework

is provided, which can be utilised to mitigate the negative impact of the sustainability challenges facing the FMCG systems in Oman. This article contributes to the FMCG supply chain sector literature by identifying the critical impact of supply chain challenges on SSCP. The study establishes a novel LSS framework and an AHP model, that will enable managers to prioritise supply chain challenges about their sustainability. This study applied two methodologies, template analysis and AHP, to obtain qualitative and quantitative results that can be applied in real-life FMCG settings to improve SSCP.

2. Direction for Future Research

Practical implementation of the research findings in a case study was not practical in this study, due to time limitations. To maximise the impact and observe improvements and potential challenges, the outcomes should be applied in the FMCG supply chain in Oman. Results were derived using template analysis and AHP techniques, which have their associated limitations such as uncertainties, bias, and lack of prescribed procedures (Nasiru et al, 2021; Taherdoost, 2017). Similar studies can be conducted using other methods to minimise these limitations.

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RESILIENCE STRATEGIES AS DRIVERS OF HEALTHCARE SUPPLY CHAIN PERFORMANCE

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Introduction

The COVID-19 pandemic has exposed the vulnerability in the global healthcare supply chains (HCSCs), which necessitates the design and application of disruption management and supply chain resilience strategies (SCResStras) (Ahlqvist et al., 2022). HCSCs are critical due to their effects on human lives and high-value supplies, requiring prioritisation of access to medical supplies over cost reduction and revenue increase (Aldrighetti et al., 2019; Savage et al., 2021). Resilience in HCSCs refers to the ability to tolerate, absorb, and recover from shocks (Thakur and Mangla, 2021). SCResStras should be embraced to address supply chain disruptions (SCDs) and enhance HCSC performance (Prataviera et al., 2022).

Oman's healthcare supply chain has faced challenges such as overcapacity, dead stock, market volatility, and disruptions, leading to longer lead times (Taderera et al., 2018). However, recent improvements, including enhanced release and tracking systems, have improved Oman's HCSC (Al-Abri et al., 2018). Nevertheless, the COVID-19 pandemic has demonstrated the susceptibility of HCSCs to disruptions, which require effective SCResStras to ensure the viability of healthcare practices (Xu et al., 2022). However, Despite the importance of SCResStras in minimising disruptions and improving performance, there is a dearth of research regarding their application in Oman's healthcare sector (Mahdi et al., 2022). No study has explored SCResStras in Oman or neighbouring Gulf countries with similar characteristics, such as Qatar, Kuwait, and Bahrain (Al Balushi et al., 2011). To address this gap, this study aims to evaluate the effects of SCResStras on disruptions in Oman's healthcare systems. The research objectives include exploring healthcare SCDs, identifying SCResStras, examining their effectiveness, and proposing recommendations for deployment to enhance the performance of Oman's healthcare sector. Addressing the research gap identified will facilitate the understanding and application of SCResStras in managing disruptions in HCSCs.

2. Literature Review

2.1 Healthcare Supply Chains

HCSCs play a crucial role in improving patient care and enhancing the value of healthcare activities (Golec and Karadeniz, 2020). Due to their high value and direct impact on human lives, HCSCs are often separated from regular supply chains (Aldrighetti et al., 2019). The availability and proper handling of medical supplies are essential for optimal effectiveness (Sathiya et al., 2023). Effective resource utilisation and excellent care at the right time and a fair price are crucial for the quality of healthcare services (Golec and Karadeniz, 2020). Optimal supply chain decisions can significantly benefit healthcare organisations (Phares et al., 2021). HCSCs encompass various supply chain management components such as sourcing, operations, logistics, and information and money movement (Falasca et al., 2021). The main objectives of HCSCs include the timely delivery of medical goods and services to healthcare professionals and patients, minimising environmental impacts on product shipping and storage, and ensuring end-to-end visibility and control throughout the supply chain (Sathiya et al., 2023). The healthcare industry structure is complex, involving supply-side designations and providing services to patients on demand (Phares et al., 2021). The COVID-19 pandemic has increased awareness of HCSC management, as it caused disruptions in over 80% of the healthcare industry (Phares et al., 2021). Supply chain issues during the pandemic include planning, sourcing, production, warehousing/distribution, and sales (Sathiya et al., 2023). Effective HCSC management is crucial for increasing value within the healthcare system, enhancing healthcare delivery, and reducing waste. Healthcare networks are pressured to innovate and develop new models to improve supply chain performance (Phares et al., 2021).

2.2 Supply Chain Disruptions in Healthcare Systems

SCDs in healthcare systems have gained increasing attention due to globalisation and the impact of the COVID-19 pandemic. The complexity of global supply networks has made effective supply chain management crucial for organisations

(Maheshwari et al., 2021). The vulnerability of HCSC has been highlighted by the pandemic and the frequency of global crises (Xu et al., 2022). Stakeholders have become more interested in SCDs, considering the importance of ensuring access to medical supplies during disruptions (Comite et al., 2020). The disruptions to HCSC can be categorised into six groups: supply, demand, operational, logistical, political, and natural (Jaberidoost et al., 2013). Supply-related disruptions include issues with material quality and delivery flexibility, while demand-related disruptions involve fluctuations in demand and shortages of medical supplies (Enyinda et al., 2014). Operational disruptions encompass infrastructure failures and longer supply lines, while logistic disruptions involve transportation and fluctuating fuel prices (Pesel et al., 2022). Trade restrictions and border closures can pose threats to the supply chains for medical supplies (Jaberidoost et al., 2013). Natural catastrophes and pandemics, such as COVID-19, disrupt HCSC by interfering with medical operations (Enyinda et al., 2014). Effective disruption management is essential for maintaining patient safety, health, and healthcare services (Sukwadi and Ceasar, 2022). Resilience in HCSC systems involves withstanding shocks, absorbing them, and recovering quickly through repair and preservation (Thakur and Mangla, 2021). Disruption management includes identifying and evaluating disruptions, prioritising them, and applying mitigation techniques (Sukwadi and Ceasar, 2022). Once disruption assessments are performed, SCResStras can be implemented to control and eliminate disruptions (Sibevei et al., 2022). These approaches aim to improve patient care quality, manage disruptions, and reduce inefficiencies in HCSC (Enyinda et al., 2014).

2.3 Supply Chain Resilience Strategies for Managing Disruptions in Healthcare Systems

Supply chain resilience (SCRes) is essential in healthcare systems to ensure the continuous supply of medical equipment and essential resources during disruptions (Singh et al., 2021). SCRes refers to a system's ability to anticipate, detect, and protect itself from interruptions without significant adverse effects (Hussain and Papastathopoulos, 2022). Two central pillars of SCRes are resistance and recovery. Resistance involves reducing the impact of disruptions, while recovery focuses on the system's ability to return to normal operations after a disturbance (Lohmer et al., 2020). To enhance SCRes, several strategies can be employed. These include readiness, responsiveness, and recovery (Powell et al., 2021). Readiness strategies aim to minimise the impact of disruptions and consider all potential disturbances and deviations (Vimal et al., 2022). Collaboration within the supply chain, such as information sharing, decision coordination, resource sharing, cooperative communication, and goal alignment, has been proven effective in building resilience (Lohmer et al., 2020). Strategies like safety stock and multiple sourcing also help mitigate disruptions by ensuring capacity and managing risks (Bret et al., 2021). Responsive strategies focus on reacting swiftly to disruptions and market demands (Chowdhury et al., 2013). Agile management, which involves making quick changes and following guidelines for decision-making, can enhance responsiveness (Carissimi et al., 2022). Flexibility and redundancy are also essential responsive strategies, allowing for quick adaptation and alternative options during instability (Carissimi et al., 2022; Tukamuhabwa et al., 2015). Recovery strategies aim to restore normal operations and are evaluated based on recovery time (Chowdhury et al., 2013). Contingency planning, which involves restructuring the supply chain and resource management, is crucial for effective recovery (Lohmer et al., 2020). Automated contract functionality can facilitate contract execution during disruptions, enabling quick implementation and minimising errors (Lohmer et al., 2020). Reserve inventory is also recommended as a recovery technique to control disruptions (Chowdhury et al., 2013).

3. Methodology

The research methodology employed in this study is a mixed methodology approach, utilising both qualitative and quantitative techniques such as interviews and surveys to gather and analyse data (Katsaliaki et al., 2022). The study aims to investigate the impact of SCRes policies on disruptions in Oman's healthcare systems. The research philosophy adopted is pragmatism, as it allows for operational judgments based on what will work best to address the research problem (Alharahsheh and Pius, 2020). The research approach is abductive and focuses on developing hypotheses from data analysis (Teherani et al., 2023). Purposive sampling was used to select participants for the interview and survey, and relevant supply chain strategic decision-makers and managers in Oman's healthcare sector were recruited for this study (Etikan et al., 2015). Primary data was collected through interviews and surveys, while secondary sources were used to acquire literature data (Bastani et al., 2021). The data analysis process involved phase I, qualitative template analysis, and phase II, quantitative Analytical Hierarchy Process (AHP), to examine both primary and secondary data sources (Vostanis et al., 2023). The findings from this analysis provided an understanding of SCResStras for managing disruptions in the healthcare system of Oman and identified the optimal SCResStras for each disruption.

4. Results and Discussion

4.1 Phase I Results

A qualitative template analysis was conducted in research phase one to identify additional strategies for managing disruptions in Oman's healthcare system. The analysis involved interviews and a literature review to gather expert opinions and determine if any SCResStras in Oman HCSCs. The coding template used in this analysis was initially based on a subset of data and was updated as new data became available (Zubairu et al., 2021). The initial template consisted of higher-order themes such as redesign, recovery, responsiveness, and readiness. Three of these themes aligned with the findings from the literature review. However, redesign emerged as a new higher-order theme specific to Oman's healthcare system. The template further revealed other variables as sub-themes under the higher-order themes. The final template incorporated additional data from interview transcripts and literature reviews to identify key SCResStras for managing SCDs in Oman's healthcare sector. Iterative corrections were made to ensure accurate data recording, which was crucial for recommending management and mitigation strategies (McCaig et al., 2023). The final template included new sub-themes while retaining the higher-order themes. The identified SCRes strategies for managing disruptions in Oman's healthcare system encompass four main categories: readiness, responsiveness, recovery, and redesign. Under readiness, collaboration, safety stock, sourcing, and integration were highlighted as important strategies. The responsive category included agility and flexibility, while recovery involved contingency plans and reserve inventory. Redesign encompassed infrastructure redesign, supply chain process redesign, and technology integration such as artificial intelligence (AI), cloud systems, and the Internet of Things (IoT).

4.1.1 Phase I Discussions

This study identified four higher-order themes for SCResStras in controlling disruptions in Oman's healthcare systems: readiness, responsiveness, recovery, and redesign. Readiness strategies emerged as crucial, emphasising preparedness and collaboration with suppliers and partners. Safety stock and sourcing were identified as essential tactics, although maintaining warehouse inventory can increase holding costs. Auto-replenishment was suggested to mitigate this drawback (Bret et al., 2021). Responsive strategies highlighted the importance of supply chain flexibility and agility, with local procurement is seen to enhance agility. Quantity and logistical flexibility were emphasised for resilient organisations (Tukamuhabwa et al., 2015). Recovery strategies were deemed vital for survival, with contingency plans and reserve inventories as crucial tactics to manage disruptions (Chowdhury et al., 2013). Redesign strategies not highlighted in the literature review were identified as necessary. Outdated infrastructure and technology in Oman's HCSCs were recognised, which requires upgrades. This can be facilitated by implementing technologies such as AI, cloud systems, and IoT. The findings underscored the significance of systems, technology, and process improvements for achieving resilience (Ivanov et al., 2017). This study integrated interview findings with insights from the literature, providing a comprehensive understanding of SCResStras for controlling disruptions in Oman's healthcare systems. Overall, the study emphasises the importance of being prepared, collaborating with suppliers, and implementing safety stock and sourcing strategies to enhance readiness. It highlights the need for supply chain flexibility, agility, and local procurement to improve responsiveness. The study also stresses the significance of contingency plans, reserve inventories, and infrastructure upgrades to ensure adequate recovery from disruptions. The importance of redesigning outdated infrastructure and technology is emphasised to enhance SCRes in Oman's healthcare systems.

4.2 Phase II Results

In the second phase of this study, quantitative data was analysed using AHP to analyse and assess the relative importance of each resilience strategy in addressing SCDs in Oman's healthcare system. The objectives, criteria, and alternatives were deduced from the findings from the literature review and the qualitative analysis to develop the AHP hierarchy. This facilitated the ranking of the four SCResStras based on their relative influence on the six SCDs in Oman's healthcare systems. The six major SCDs, including supply, demand, operational, logistics, political, and natural disruptions are utilised as the criteria, and evaluated using a pairwise comparison to establish their relative impacts on HCSC performance as shown in Table 1.

Table 1. Criteria for supply chain disruptions

Criteria		Preference
Supply	C1	0.126
Demand	C2	0.226
Operational	C3	0.180
Logistics	C4	0.118
Political	C5	0.149
Natural	C6	0.201

The four SCResStras are employed as the alternatives, which are evaluated based on their influence on each criterion. This evaluation facilitates the ranking of the SCResStras based on their efficacies towards addressing SCDs in Oman's healthcare system as presented in Table 2.

Table 2. Alternatives for resilient strategies

Alternative	C1	C2	C3	C4	C5	C6	Sum	
Readiness	A1	0.442	0.400	0.137	0.368	0.304	0.312	0.327
Responsiveness	A2	0.251	0.212	0.305	0.229	0.202	0.260	0.243
Recovery	A3	0.188	0.232	0.303	0.186	0.328	0.288	0.254
Redesign	A4	0.118	0.156	0.225	0.217	0.166	0.140	0.170

4.2.1 Phase II Discussion

Deploying the AHP approach in this stage validates and extends the conclusions drawn from the first phase. It provides a structured and systematic framework to assess the relative importance of various resilience strategies in addressing SCDs in Oman's healthcare system. The preliminary findings revealed that interruptions in demand significantly impact Oman's healthcare systems, which is associated with over-reliance on imported medical supplies due to a shortage of local manufacturers (Taderera et al., 2018). The shortage of medical supplies leads to interruptions in HCSCs, as importing products from outside Oman often results in longer lead times and higher costs (Ghadir et al., 2022). However, logistical problems, such as increased gasoline prices, have minimal impact on the Omani HCSCs. This is attributed to the government's imposition of a cap on fuel costs, which ensures that the government absorbs any significant increase in oil prices, as a subsidy (The National News, 2021). Although template analysis has emphasised readiness strategies and the need for rebuilding processes and infrastructure, particularly regarding technology, the AHP results highlighted the importance of both readiness and recovery strategies.

4.3 Recommendations on Deploying Supply Chain Resilience Strategies

This work presents SCResStras for addressing SCDs in Oman's healthcare system. The study identified demand interruptions and natural disasters as the most significant disruptions affecting Oman's HCSCs. However, findings suggest that these disruptions can be managed by implementing readiness and recovery strategies (Enyinda et al., 2014). Readiness techniques such as collaboration, safety stock, diversified sourcing, logistical flexibility, and supply chain integration can enhance preparedness in HCSCs and improve performance (Lohmer et al., 2020). Recovery measures, including reserve inventory, intelligent contracts, and contingency plans, help mitigate disruptions' impact (Carissimi et al., 2022). The Ministry of Health and the government of Oman can play a vital role by setting explicit goals and implementing resilience initiatives in its healthcare systems. Further, integrating modern systems and technology, such as AI, cloud computing, and IoT, can enhance the overall effectiveness of Oman's HCSC and increase its resilience to potential interruptions (Ivanov et al., 2017). Implementing SCRes strategies and reforming the healthcare system through integrating advanced technologies is necessary for performance improvement (Tukamuhabwa et al., 2015).

5. Conclusions, Implications and Direction for Future Research

A comprehensive assessment of the impact of SCResStras in addressing disruptions in Oman's healthcare systems is presented. The research problems were outlined, along with the methods used in addressing such issues. Qualitative and quantitative analysis are employed in research phases one and two to identify and prioritise resilience strategies. The SCResStras include readiness, responsiveness, recovery, and redesign. Recommendations for implementing the SCResStras in Oman's healthcare systems are proposed, including setting explicit rules and objectives and reforming infrastructure, technology, and systems.

5.1 Practical Impact

Rigorous analysis across two phases enables this study to establish a connection between SCDs and SCResStras in Oman's healthcare systems. Findings can facilitate the attainment of good health and well-being (Sustainable Development Goal 3). The SCResStras established can be prioritised and applied in the value streams of Oman's HCSCs, and similar countries and related networks. This study provides a blueprint for how SCDs and supply chain strategies can be identified and prioritised to address SCDs using a combination of template analysis and AHP techniques. This can be utilised by supply chain participants, relevant authorities, and other stakeholders to guide decision-making and improve overall supply chain performance.

5.2 Research Impact

This study highlights the scarcity of research on SCDs and SCResStras in Oman and the Gulf region in general and makes efforts to investigate this phenomenon and examines its impacts, thus contributing to the body of literature on the field. The research follows a defined theoretical and methodological foundation. The study reveals various areas for further investigation. Qualitative and quantitative approaches are employed to address the research problem, and the procedures can be utilised to conduct comparative studies in other supply chain networks.

5.3 Directions for Future Research

Future research should employ a comprehensive approach involving extensive interviews with a larger sample size to enhance the validity of the conclusions. Additionally, investigating different Gulf countries' HCSCs and comparing the findings can help in establishing a regional holistic framework and enhanced implications for such a study. Conducting a similar study a few years post-Covid-19 should minimise respondents' bias due to emotions and sentiments attached to the effects of the pandemic in various supply chain systems.

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EXPLORING SUSTAINABILITY PRACTICES IN GULF COOPERATION COUNCIL PETROCHEMICAL SECTOR SUPPLY CHAINS

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Introduction

The six Gulf Cooperation Council (GCC) countries of the Kingdom of Saudi Arabia (KSA), the United Arab Emirates (UAE), Bahrain, Qatar, Kuwait and Oman derive much of their gross domestic product (GDP) from the oil & gas (O&G) industry (World Bank, 2022). Notwithstanding criticisms of this industry's sustainability profile generally across the globe, the GCC is committed to improving sustainability in this industry and its petrochemical sector through enacting regulation, developing standards and practices, and monitoring environmental performance, and has also committed to international agreements such as the Global Methane Pledge and COP26.

The petrochemical sector of the O&G industry is a downstream customer of O&G producers and is responsible for refining and processing and then selling on various product derivatives from crude oil and natural gas feedstocks, more commonly referred to as 'fossil fuels.' Products derivatives include petrol, diesel, kerosene and other fuels, plastics, and fertilizers. Customers of this sector include manufacturing companies, agricultural businesses, and fuel retailers. The sector is heavily regulated as regards quality and safety, but pricing of crude oil and natural gas, and hence its product derivatives, is based on monopolistic market competition (MacFadyen & Watkins, 2014) and fostered by large oil producers such as BP, Shell and Exxon, and the Organization of the Petroleum Exporting Countries (OPEC), whose mission is to "coordinate and unify the petroleum policies of its member countries... ensure stabilization of oil markets... to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital" for investors (OPEC, 2023). KSA, UAE and Kuwait are the only GCC countries who are members of OPEC.

The oil & gas industry has been subjected to growing scrutiny from various stakeholders pertaining to its health, safety, and environmental standards. Previous disasters both onshore and offshore, from the Piper Alpha offshore platform accident in 1988 through the shipwreck of Exxon Valdez in 1989 to the Deepwater Horizon offshore platform accident in 2012, the latter two events spilling huge quantities of crude oil off the Alaskan coast and into the Gulf of Mexico respectively, have reinforced this scrutiny (Silvestre et al., 2017). And yet, analysis of 30 oil & gas company sustainability reports found inconsistency in sustainability reporting practises, which lagged behind social performance reporting (Ahmad et al., 2016). Further, there was a lack of supply chain indicators in the sustainability reporting guidelines, underlying findings from Shaw et al. (2021) that sustainable supply chain performance measurement remains deficient among supply chain companies. Hence, there appears to be a 'sustainability paradox' between environmental ambition, strategy for investors noted by MacFadyen & Watkins (2014) and practice in many firms, including oil & gas companies (Silvestre et al., 2017).

The exploratory study reported in this paper investigated how (GCC) petrochemical companies are implementing sustainability into their supply chains to identify sustainable best practices, performance measurement methods, and related drivers and barriers used within those supply chains by adopting an Institutional Theory perspective.

Literature Review

The literature review focussed on three main themes surrounding supply chain management (SCM) in the context of the GCC's petrochemical sector: sustainability and sustainable supply chain management, sustainable supply chain performance measurement, and supply chain risk management.

Sustainability and sustainable supply chain management

The primary definition for SCM relates to a throughput process of goods and services from point of origin to point of consumption with attendant relationships among various supply chain actors, including a 'focal firm' and its suppliers,

customers and other stakeholders such as government and non-government organisations (Grant, 2012). The oil & gas industry and its petrochemical sector are primarily throughput process industries of basic commodities – petrol or diesel fuels sold to consumers and other customers comprise the same basic source of crude oil, albeit refined slightly differently.

Stakeholders are particularly important regarding sustainability in supply chains and SCM as ‘influencers’ or ‘rule makers’ in the case of governments and relevant non-government organisations (NGOs), such as accounting standards bodies (Grant et al., 2022). Any regulations or standards likely also accrue to actors along the supply chain, upstream and downstream (Grant, 2012), particularly in the oil & gas industry which is more heavily regulated than some other industries (Silvestre et al., 2017).

Carter & Rogers (2008) were among the first scholars to delineate sustainable supply chain management (SSCM) as the strategic, transparent integration and achievement of an organisation’s social, environmental and economic goals in the systemic coordination of key interorganizational business process is for improving the long-term economic performance of the individual company and its supply chains. Much literature about SSCM has been developed since Carter & Rogers’ theoretical contribution 15 years ago (see Khan et al., 2021 for a recent and useful compendium on this topic), however much work remains on SSCM measurement and indicators (Shaw et al., 2021).

Sustainability performance measurement

Performance measurement and performance indicators, also referred to as key performance indicators or KPIs, have been commonplace in business and companies for many decades. Traditionally, supply chain performance measures have been orientated around cost, time, and accuracy. A key issue surrounding performance measurement is what to measure and how to measure it (Grant & Shaw, 2019). In contrast, sustainability performance measurement is a recent development due to increasing interest over the last 20 years concerning issues of climate change, diminishing raw materials, a need for cleaner production and excess waste reduction, increased levels of pollution, globalisation, and gaining a competitive advantage from sustainability (Shaw et al., 2021).

A great deal of research and practice on sustainable supply chain performance measurement has focused on reducing greenhouse gas (GHG) emissions due to their overwhelming impact on climate change. However, companies have recently begun seriously considering broader sustainable management issues, not only from a mitigation legislative perspective, but also from an adoption perspective. The adoption of additional sustainable measures, whether accredited, audited or not, will provide a company with an environmental management system (EMS) to manage and report on its environmental performance (Grant & Shaw, 2019). The problems caused by materials (e.g., pollution) or infrastructure added to the system or removed from the system (e.g., aggregates,) requires a risk assessment framework. This is then managed using the actions through vertical integration of governance and the horizontal integration of stakeholder action.

Supply chain risk management

Risk management has always been important for companies and supply chains in many industries (Rafi-UI-Shan et al., 2018), but even more so since the COVID-19 pandemic disrupted world economies and global supply chains, regardless of country size or national economy development. Such disruptions have forced all companies to investigate and evaluate the risks and vulnerabilities within their supply chains (Gurtu & Johny, 2021).

There is some disagreement among scholars regarding a definition of supply chain risk management (SCRM), however there is concurrence that SCRM practices seek to reduce supply chain vulnerability and mitigate the impact of disruptions (Rafi-UI-Shan et al., 2018). These practices lead to action seta for an intended result, requiring a prerequisite for coordination and collaboration among supply chain actors to identify, assess, mitigate and monitor risks to reduce vulnerability and increase robustness and resilience of the supply chain, ensuring profitability and continuity (Baryannis et al., 2019).

The oil & gas industry, and its petrochemical sector, deals with dangerous materials at different stages in its supply chain. If these materials are treated in unsustainable ways, they may negatively impact a company’s operations and its workforce, as well as society or the environment. Further, the global reach the GCC’s petrochemical sector leads to one of the most extended supply chains worldwide. Such a long supply chain has a greater risk of disruption or failure.

Risk is thus the primary source of disruption, which may ripple through a supply chain, and the role of SCRM is to ensure

smooth functioning and risk-free supply chains functions. Hence, SCRM is a vital function as it deals with unexpected challenges facing companies related to the economy and globalisation, which increases uncertainty facing the supply chain (Gurtu & Johnny, 2021). For this reason, exploration of supply chain sustainability in the GCC petrochemical sector, or indeed anywhere in the world, must consider issues of SCRM.

Literature summary and resultant research questions

Sustainable supply chain performance measurement is thus a multidimensional, complex business problem. Issues such as non-standardised data, access to data, technology restrictions, stakeholders, culture, products, government regulations, organisational policy, industry and sector, country, and company size can all negatively drive or act as a barrier to the implementation of efficient and effective sustainable supply chain performance measures and practices. Three research questions were derived to investigate this phenomenon in GCC petrochemical supply chains:

- RQ1: What are the best sustainable supply chain practices to implement among petrochemical companies in GCC countries?
- RQ2: What is the best performance measurement system to be used for measuring the impact of sustainable supply chain management practices, and what should be measured by GCC petrochemical companies?
- RQ3: What are the drivers and barriers to implementing sustainable supply chain management practices in GCC petrochemical companies?

Methodology, Findings and Discussion

Theoretical framework, methodology and methods

Institutional Theory (IT) is the framework applied in this context given the variety of stakeholders and institutions in the GCC petrochemical sector industry, particularly governments regarding promulgation of legislation and regulations for health, safety, and the environment (Ahmad et al., 2016, Silvestre et al., 2017).

IT is a well-developed theory from DiMaggio & Powell (1983) and contains three aspects of isomorphism, which is a constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions. There are three mechanisms of institutional isomorphism: coercive, mimetic and normative. Coercive isomorphism comes from political influence and deals with legitimacy problems. Mimetic isomorphism is associated with standard responses to uncertainty. Normative isomorphism is linked with professionalisation. For example, there are three sources of potential coercive isomorphism in the GCC petrochemical sector: the six GCC governments, the overall GCC council, and the NGO Gulf Petrochemicals Chemicals Association (GPCA). The GCC governments represent elevated pressures while the GCC council and GPCA represent informal pressures alongside international environmental standards. Finally, customers and competitors in international markets can critically influence sustainability implementation.

A case study approach was used for primary research with companies in the GCC petrochemical sector, as well as governments and NGOs. A purposive sampling technique was used to select participants able to participate in the study and conveniently accessible. Selection was based on several factors such as position within their organisation, and relationships and knowledge about sustainability and supply chain management. Not all GCC countries chose to participate in the research, only KSA, UAE and Kuwait (the three GCC members of OPEC). Thirty-two, semi-structured interviews, comprising 17 primary questions with probing sub-questions, were conducted with respondents from petrochemical companies (n=28), government (n=2) and NGOs (n=2). Secondary data published by the companies, governments and NGOs was examined to provide supplemental or additional information. NVivo12 was used to code interview transcripts to find themes and interrelations in subsequent analysis.

Findings for RQ1

Six key findings emerging from RQ1 about the best sustainable supply chain practices are:

1. Despite probing, not many respondents discussed sustainability or possible negative environmental impacts of this sector that deals with many high-hazard and high-risk materials, for example a teaspoon of some petrochemical liquid waste is enough to pollute 25,000 cubic meters of seawater. This might be due to a lack of respondent awareness about sustainability outside other practices.
2. Benchmarking by itself is considered a crucial practice for the supply chain, including sustainability. Without a benchmark, companies will not know if they have best practices or not. It is also considered crucial to have a database for the benchmark.
3. Four main themes were derived from respondents regarding the best supply chain practices and are considered pillars of supply chain best practices for GCC petrochemical companies. The four pillars are digitalisation, value creation, risk management, and partnership.
4. Respondents believe the supply chain's primary role is to create value for the business, not cost reduction. Value creation aims to make the supply chain a strategic department and share in the company's decisions. However, they note that creating value requires creativity.
5. In the GCC there is a focus on sustainability inside factories or operational units, which includes health and safety, but the situation is different outside them and requires improvement. Risks surround this sector so sustainability must be considered both internally and externally. In addition, companies will not have a sustainable supply chain without risk management as uncertainty is the most significant risk facing them.
6. Partnerships can be with competitors through a buying consortium, which is one of the sourcing practices. They enhance a company negotiating positions, promote shared costs between companies, and enhance sustainability for all.

Findings for RQ2

Six key findings from RQ2 about the best sustainable supply chain measurement system and measures are:

1. Unexpectedly, performance measurement systems such as balanced scorecard (BSC) and the supply chain operations reference (SCOR) model are not used in GCC petrochemical companies; the prime source of performance measurement are KPIs.
2. GCC petrochemical companies give more weight to customer satisfaction than any other element related to cost.
3. Further they also give more weight to customer satisfaction than their sector's sustainability or environmental impact. This again may be due to a lack of sustainability awareness.
4. When it comes to sustainability KPIs, GCC petrochemical companies give much more weight to accident rates than CO₂ emissions. This demonstrates why petrochemical companies in the GCC have excellent records when it comes to accidents and health and safety, but not other environmental issues.
5. In KSA, the Royal Commission of Jubail and Yanbu are playing crucial roles in monitoring the environmental performance of the petrochemicals sector and the implementation of international environmental agreements.
6. This research determined the most important sustainability KPIs identified by respondents for use by petrochemical companies, which are presented in Table 1.

Sustainability KPIs	Number of respondents
Accident rates	22
Percentage waste	17
Energy consumption	17
Percentage related to corporate social responsibility (CSR)	17
CO ₂ emissions	15
Usage of recycled materials in operations	11
Product loss / leakage	1

Table 1: Sustainability KPIs noted by respondents

Findings for RQ3

Twelve key findings from RQ3 about the drivers and barriers to implementing sustainable supply chain practices are:

1. The primary drivers and barriers regarding sustainability implementation in GCC petrochemical companies are noted in Figure 1.
2. Sustainability from respondents' viewpoints has different definitions, but these definitions reinforce findings discussed above about a lack of sustainability understanding. Also, definitions discussed were not comprehensive.
3. The mindset of leaders in the GCC, whether belonging to companies or governments, is the most critical internal and external driver for sustainability in the GCC, even more than regulations and sustainability costs. Without believing in sustainability, leaders will play around with regulations to avoid costs.
4. In the GCC, most company respondents favour not having a special department for sustainability. They believe sustainability must be embedded in the DNA of companies. When sustainability is limited to a department, costs will increase, and other departments may feel that they have nothing to do with it.
5. In the GCC, partnerships with global companies have contributed enormously to the success of the petrochemical sector, built a good culture, transferred knowledge, and enhanced sustainability.
6. In the GCC, government leaders are drivers of sustainability. For example, in KSA the government's Vision 2030 has transformed the country in many different ways, including the oil & gas industry, for a more differentiated and sustainable economy and including many sustainability initiatives. This has also changed many regulations, practices, and standards so that they are at the global level. Further, it has changed the government's mentality, making it more business orientated.
7. In a context unique to the GCC, due to the requirement for petrochemical companies to compete in global markets, the companies are much more developed than governments. The companies regulate themselves as opposed to waiting for government enforcement.
8. In recent years, governments have been essential to GCC sustainability, and not only through putting regulations in place. They have introduced new and updated standards, programs and practices enhancing sustainability. This is due to changes in governmental leadership, the mindset of governments to be more business-oriented, and the development of various initiatives such as the KSA Vision 2030.
9. In GCC, one of the significant barriers to sustainability is the level of awareness and a lack of knowledge. The NGOs are responsible for increasing sustainability awareness and knowledge and play a crucial role in dealing with this barrier through conferences, building databases, increasing awareness, publishing reports, and sharing knowledge and practices among the industry and governments.
10. The GCC region is different from other parts of the world. Apart from qualified people, the cost and resources are not significant barriers. The main barriers, based on respondents' beliefs, are related to qualified people, awareness and the culture of sustainability.

11. Sustainability awareness and culture are two main external barriers to implementing sustainability in the GCC. Societies in the GCC accepting to paying a premium on prices for sustainability is an indicator of people reaching the right level of awareness and imbedding a culture of sustainability.
12. Governments in the GCC must change management programs to prepare people to understand the risks and adopt sustainability in everything. This could be achieved by education.

Conclusions

Contributions to theory

1. First study to provide a deep, qualitative understanding of the GCC petrochemical sector context pertaining to sustainability and its importance for companies, governments, and NGOs.
2. Study identified best sustainability practices via the emergent four pillars of digitalisation, value creation, risk management, and partnership to address RQ1 and RQ2.
3. Study identified key drivers and barriers for implementing sustainability practices in the GCC to address RQ3.
4. Study informs Institutional Theory as elements all three institutional isomorphic pressures, coercive (internal and external pressures on companies), mimetic (a belief in benchmarking), and normative (working with governments and NGOs including universities), all influence and impact the GCC petrochemical sector.
5. Partnerships and self-regulatory practices emerged as important drivers for implementing sustainable supply chain practices beyond the usual Institutional Theory elements.

Drivers					Barriers			
Internal	Within a company	The mindset of company leader			Lack of resources	Financial Resources		Internal
		Reduce the cost in the long-term				Technological Resources		
		The sustainability structure				Qualified People		
		Company Recognition				Sustainability Awareness and Culture		
		Digitalization			Sustainability Cost			
		Partnership						
		Products stewardship						
External Drivers	Licence to operate			Sustainability Awareness and Culture	In Societies		External Barriers	
	Globalization				In Governments			
	Build the awareness of Sustainability			Bureaucracy				
	Build the Culture			The level of Sharing Information and Knowledge Management				
	Educate People			Lack of Communication between Governments and the Industry				
	International Standards			Lack of Transparency				
	Governmental Drivers	Governmental Leader Mindset			Availability and Cost of LSPs and Recycling Companies			
		Regulations	Regulation enforcement		Availability of Pipelines and Railways Networks			
			Incentives and Punishments					
			Self-regulator Companies					
		Governmental Standards						
		Governmental Programs	Energy Efficiency Programs					
			Authorized Economic Operators AEO					
			Degradable Packaging Materials					
			Local Content					
			Royal Commission Practices	Monitoring Systems	Continues Emission Monitorin g System CEMS			
					Fence Monitorin g System			
				Reporting Environmental Performance to the Royal Commission				
		Controlling Waste Movement						
	NGOs Drivers	GPCA Practices	Knowledge Sharing					
			Legal Supports					
			Safety and Quality Assessment for Sustainability SQAS					
			Responsible Care Program					
			Benchmark Environmental Performance (Eco-Profile)					
			Database for the Industry (Fact and Figure Report)					
		The Association of Supply Chain and Procurement- Saudi Arabia	Provide Database					
			Build Awareness of Supply Chain in companies and Government					

Figure 1: Sustainability drivers and barriers noted by respondents

Contributions to practice

1. Developed the four pillars and determined related KPIs to provide guidance for the GCC petrochemical sector, and other oil & gas industry companies, governments and NGOs, regarding applying changes to extant business models to improve sustainability best practice.
2. The GCC petrochemical sector, and oil & gas industry, needs to prepare for a digital ecosystem after Industry 4.0 through integration and a Supply Chain Control Tower.
3. Provided eight policy recommendations for governments to enhance sustainability implementation including inter alia fostering local content, building a sustainability culture, improving bureaucracy, and building supply chain infrastructure networks among GCC countries.

Limitations and future research

Study comprised a small sample from one sector, petrochemical companies and relevant stakeholders, in the GCC. Hence, while results are valid for this context, they are not necessarily generalizable to others. Future research should expand the scope of study to other regions to test the four pillars and sustainability best practices and KPIs found in this research. This study's methodology and methods could also be applied to other industries and sectors.

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DIGITALISATION AND MARKETING CAPABILITY IMPACTS ON INTERNATIONAL BUSINESS PERFORMANCE: AN EMPIRICAL STUDY

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1. Introduction

Internet and new technologies have changed the way society and businesses communicate. These new technologies provide opportunities such as managing websites, having social media accounts, and being connected online anywhere and anytime. Notably, the way businesses communicate with their customers has changed with the advancement in digital (online) marketing tools (Melović et al., 2020). On the other hand, digital marketing tools help consumers access information without limitations of time and location.

Since the business environment changes very quickly, it is suggested that businesses should take into account rapidly changing environment while adapting their digital strategies (Coreynen et al., 2020). To cope with these changes in a competitive market, innovation is critical for an organization to survive (Tajudeen et al., 2022). Benefitting from such new innovative digital technologies not only helps to improve such marketing capabilities for businesses but also brings new opportunities for businesses to create an advantage in the competitive market and enter foreign markets for better international business performance. In line with their intended competitive goals, managers and policymakers can use digitalisation to enhance their business's internationalisation plans (Lee & Falahat, 2019).

This paper is organized into five sections. Following the introduction, in the second section, a review of the literature that presents results of previous research regarding digitalisation, marketing capabilities and international business performance, as well as a literature review in which the motivations behind this research and research gap in the area are outlined. The third section presents a conceptual framework, including a conceptual model and hypothesis. The following section provides the methodology, outlines the research methodology, i.e. data collection, sampling, measures, and analysis. The next section presents the results of the research and discussions of the results. Finally, the paper finishes with concluding remarks, a review of the theoretical and practical implications, an elaboration of the research limitations, and recommendations for future studies in this area.

2. Theoretical Background

Digitalisation and Marketing

Digitalisation is defined by Quarato et al. (2020, p. 93) as 'a set of evolving practices consisting in adopting new digital technologies in daily organisational life, which identifies the agility as a critical component for the strategic renewal of business's business model, organisation and culture'. From Cenamor et al.'s (2019, p. 197) view, digitalisation can be explained as 'the implementation of digital technologies'. Based on these definitions, we can define digitalisation as the application of digital technologies into businesses and organisations, culture and society.

The digital technologies have been one of the most important strategic success factors for businesses (Melovic et al., 2020). The new technologies to invest and implement for a business require a precise and accurate decision-making process to find the right strategy for the business. Digitalisation has changed the business type for both sides, for businesses and for customers. From business perspective, the digitalisation of businesses helps businesses to improve efficiency, productivity, and profit (Vorhies, Harker and Rao, 1999; Yin and Falahat, 2019; Piqueras, 2020; Melovic et al., 2020). From consumers perspective, digital and web experiences are strong tools for businesses as part of internet technologies to influence and enhance consumers' online buying behaviour (Melovic et al., 2020; Liu, Zhang-Zhang and Ghauri, 2020).

Overall, by utilising cutting-edge digital information and communications technologies, businesses obtain some opportunities from digitalisation as (i) identifying opportunities for development, (ii) posing obstacles to growth, and sharing global activities (Piqueras, 2020), (iii) providing better communication and connection technologies (Guo et al., 2020; Gupta et al., 2021), (iv) gaining competitive advantage (in terms of price, product and service), (v) reducing costs and savings time in international markets (Lee & Falahat, 2019), (vi) providing information which business use for better crisis management such as pandemics and any other disruption (Guo, Yang, Huang and Guo, 2020).

Businesses can create different values from digitisation to transform existing business models and/or develop new ones, from marketing and sales channels to logistics (Piqueras, 2020). In order to complete digitalisation, businesses benefit from digital tools to complete digital transformation. Digital transformation means “the process of using digital technologies to create new—or modify existing—business processes, culture, and customer experiences to meet changing business and market requirements” (Sales force 2019 in Melovic et al., 2020, p.14). At the end of digital transformation, businesses have a chance to change their business environment into e-commerce, e-business and e-marketing (Cassetta et al., 2020). As a result of digitalisation, businesses benefit from a variety of digital tools and technologies such as websites, High-speed internet and Wireless technology, e-commerce, big data analytics, social media, internet of things (IoT), Artificial Intelligence (AI), machine learning, Blockchain, and other information and communications technologies (ICTs) and etc. (Yin and Falahat, 2019, Cassetta et al., 2020, Piqueras, 2020).

Digital marketing tools use digital technologies for integrating, targeting and measuring the communication tools that are used to obtain and keep customers and build and enhance relationships with them to be able to have more loyal customers and provide better services to them (Melovic et al., 2020; Eller et al., 2020; Kohtamäki et al., 2020; Monteiro et al., 2017). Better communication with customers, better targeting in direct, quick and continuous ways, and personalisation are all cost-efficient ways through digital marketing (Lee & Falahat, 2019; Song et al., 2008). Another benefit of digital marketing is measurable Return-on-investment (ROI). Investments in digital marketing are more measurable compared to traditional marketing methods (Melovic et al., 2020). Besides, digital marketing and media tools are the resources for the customers that can have easy access to information without the time and location limits (Yin and Falahat, 2019; Melovic et al., 2020). Social media, social networking sites are digital marketing ways that consumers and businesses contact with each other directly for information exchange about brands, generate information with collaboration with others (businesses, friends, online community members etc.) (Pinho and Prange, 2016; Melovic et al., 2020).

Digital marketing is also beneficially used by businesses to create brand awareness (Chapman & Kihn, 2009; Melović et al., 2020). Thus, it is possible to say that Internet technologies can help businesses in terms of developing better business strategies in various ways (Coreynen et al., 2020; Cassetta et al., 2020; Melovic et al., 2020). These strategies to apply digital marketing by businesses are encouraged by the mentioned benefits of digital marketing. However, every business prefers to apply digital marketing in different ways. Key factors that affect the implementation of digital marketing were determined by Melovic et al. (2020) as ‘business activity, the size of the business, the period of digital marketing implementation, forms of digital marketing, the people in charge of its application, the measurability of effects, methods of measurement, cost-effectiveness, the application of traditional marketing, and brand perception’. The reason of this variation can be explained by their capabilities which will be detailed in the following section.

Capabilities and Marketing

Business capabilities are the main factors that a business can gain competitive advantage and remain it for long-term growth and profits (Vorhies, Harker and Rao, 1999). To achieve this growth and profit, being market-driven, finding new markets, understanding, and satisfying customer needs by developing products based on customer needs, and technology use are highlighted as important factor (Vorhies, Harker and Rao, 1999). In order to bring profit and competitive advantage to the business, businesses’ resources are the key elements (Monteiro, Soares and Rua, 2017). Capabilities can be defined as the use of organisations’ available resources to create value offerings for the market (Monteiro, Soares and Rua, 2017) which they are positively related to business performance (Hao and Song, 2015).

Businesses develop different organisational capabilities. For instance, according to Hao and Song (2015), strategic capabilities can cover technology and information technology, marketing, and market-linking capabilities. The performance of a business is correlated positively across all strategic capabilities (Hao and Song, 2015). Among the capabilities, marketing and market-linking capabilities are essential to respond to complex, diverse, and fast-changing markets, especially for big companies (Hao and Song, 2015). Another core capability that enables organisations to gain competitive advantage is

manufacturing capabilities. Digitalisation can enhance the development of manufacturing capabilities in different ways. The efficiency of communication and coordination between customers and external partners through digital technologies can be used for manufacturing processes to adjust product specifications based on the information provided by their customers (Hsiao et al., 2019).

Digitalisation is stated as beneficial for finding new business opportunities to identify future needs and market trends that allow exploring new business opportunities and increasing the efficiency of the businesses by developing capabilities to understand and satisfy customer needs better (Kohtamäki et al., 2020; Monteiro et al., 2017a), to meet customers' future expectations (Eller et al., 2020). Especially for smaller size businesses, the digital capability of SMEs can increase network and marketing capability which also improves business performance (Cenamor, Parida and Wincent, 2019).

Marketing capability is defined by Inan and Kop (2018) as 'a company's ability to understand changing customer needs and to meet customers' expectations using tangible and intangible assets.' Marketing capability is related to using the resources for a better understanding of customers, their needs, rivals, and competition, segmenting and targeting the customers and building marketing strategies based on marketing mix (4P=product, price, promotion, place) (Yu, Jacobs, Chavez, and Feng, 2017). Marketing capabilities like knowing customer profiles, segmentation, and assessing market and marketing strategies increase relationships. Also, businesses should use IT and marketing capabilities to enhance information flow and communication with customers and partners by using IT technologies, thus gaining a competitive advantage (Yu et al., 2017). According to Vorhies, Harker, and Rao (1999), marketing capabilities can be classified, which are market research, pricing, product development, channels, promotion, and market management. Although they are close, it is possible to say that marketing research capabilities are more relevant to product development capabilities.

Businesses use not only marketing but various capabilities to collect market information, monitor rivals and other products, understand their existing customers, encourage networking with their customers (Pinho and Prange, 2016). As the results of Pinho and Prange (2016) show, social networks develop different capabilities in the business and positively encourage the link between international performance and social networks. In a similar vein, Liu, Zhang-Zhang and Ghauri (2020) examined how internet marketing capabilities and internet use for customer management impact international market performance. Their findings show that internet marketing capabilities are positively impacted by internet use for customer management.

International Business Performance

The literature on international business acknowledges that one of the most significant factors in business growth and increased performance is internationalisation (Joensuu-Salo et al., 2018). For many businesses, the ability to internationalise has evolved into a competitive necessity that enables their survival and growth in the face of globalisation and the knowledge economy. In the global markets, the ability to internationalise is the key competitive advantage for businesses for their survival and growth in the international markets (Joensuu-Salo et al., 2018). The importance of internationalisation for the competitiveness of businesses is increasing day by day for all sizes of businesses (Monteiro, Soares, and Rua, 2017). Thus, exporting is a strategy to enter international markets. While entering international markets is challenging for them, it is also a way to enhance their abilities and obtain competitive advantages. Improvements in export performance lead to contributions to economic growth and value creation.

Despite their limited resources for early and extensive internationalisation, smaller and younger enterprises are encouraged to expand internationally due to the features of the digital market (Wittkop, Zulauf and Wagner, 2018). There are key capabilities of businesses to stay competitive in the international markets, have control over product specification, quality, and customisation, to control productivity and production costs, display better marketing capacities which help them to enter new international markets, to respond to changes in international markets quicker in terms of regulations, identifying and satisfying customer needs or market conditions (Yin and Falahat, 2019). The ability to network keeps businesses competitive in international markets (Pinho and Prange, 2016).

There are different factors that affect the business performance. For instance, market-driven businesses perform better performance in other areas, such as financial performance (Vorhies, Harker and Rao, 1999). For instance, it is found that digital technologies can help to communicate with customers and manage customer relationships through social media (Eller et al., 2020). This affects business financial performance by reducing marketing costs. Another research supports this idea by referring that social networks help businesses to develop new capabilities due to networking and information exchange between internal and external sources (Pinho and Prange, 2016). Similarly, Kohtamäki et al. (2020) examined the

relationship between financial performance and digitalisation. This research shows that businesses with higher digitalisation show better financial performance. Easy-to-implement IT systems have a positive effect on the financial performance of businesses especially if implementation cost is not high. For the high cost of implementation, it must be supported by other business capabilities. Likewise, the findings of Khin & Ho (2019) demonstrate that digital capabilities and orientation have a beneficial impact on digital innovation and that digital innovation mediates the impact of digital capability and orientation on both financial and non-financial performance. Thus, it is possible to say that business networks enhance overall business performance (Pinho and Prange, 2016).

Export Performance

Exporting involves entering international markets and serves as one of the primary stages of internationalisation. Export markets necessitate distinct strategies compared to domestic markets (Monteiro, Soares, & Rua, 2017). The competitiveness of exports in the global market is significantly influenced by factors such as the quantity, quality, and strength of relationships with consumers and distribution networks. The research conducted by Monteiro, Soares, and Rua (2017) on Portuguese exporting businesses reveals a direct correlation between the dynamic capabilities and entrepreneurial orientation of businesses and their export performance.

According to Pham, Monkhouse and Barnes (2017), the businesses need to invest in marketing in order to get successful results in their exports in emerging international markets. Marketing capabilities are found significant for export performance, but not all capabilities. For instance, engagement in export market intelligence gathering, product development capability, and taking responsibility for export promotional campaigns and pricing lead to export success. However, enhancing distribution capabilities and after-sales service have no influence. E-business digital technologies influence businesses' export performance. Since competitiveness and internalisation is high, businesses are advised to adopt and implement digital technologies to be able to compete with large businesses (Cassetta et al., 2020).

International Market Performance

Investing in internet-based customer management systems enables the business to create more customised customer relationships, which improves global sales (Liu, Zhang-Zhang and Ghauri, 2020). Firstly, the business can improve its digital marketing capabilities for international activities the better it controls its international customer base. Secondly, the findings indicate that online marketing skills indirectly influence business performance in the global market. Internet capabilities have been found to directly affect overall business performance (Liu, Zhang-Zhang and Ghauri, 2020). Another study argues that being market-oriented contributes to business performance positively (Hao and Song, 2016). While there is a direct correlation between marketing capability and business performance, the correlation is much less than international businesses (Sanna, Kirsti, Anmari and Varamäki, 2018). In international markets, more capabilities are needed compared to domestic markets.

The e-marketing is used for the use of both marketing and Internet in the same platform that contains Internet technologies to use in customer relationship management, communication and sales management (Liu, Zhang-Zhang and Ghauri, 2020). The internet use is not only useful for competitive advantage but also useful for potential increases in domestic and international sales. It is believed that marketing capabilities affect a business's performance which these capabilities use business's abilities of understanding customer needs and building a continuous relationship (Liu, Zhang-Zhang and Ghauri, 2020). They found that not only internet, but the combination of other capabilities helps for a better performance. The ability to use the internet for customer management may have an impact on total internet marketing capability. For instance, digitalisation had little impact on how well internationalised businesses performed, while there is impact that influenced the businesses that served their own domestic markets (Sanna, Kirsti, Anmari and Varamäki, 2018). However, the impact of internet on business's international market performance is under researched (Liu, Zhang-Zhang and Ghauri, 2020).

The results can be different especially in business because of developing dynamic internationalisation capabilities (DICs) has an influence on their international performance (Pinho and Prange, 2016). Although business has been involved in increasing their foreign markets via e-commerce and use the Internet and IT technologies to promote the business and its products and/or services; for internalization, they need to go beyond just doing internet-based sales (Eduardsen, 2018). In this case, digitalisation help for the businesses have similar opportunities. With the help of globalization, businesses are affected positive way in adopting digital technologies and encouraged to benefit from more digital technologies which lowers technology barrier

among businesses and improve the competition, productivity and innovation (Skare & Riberio Soriano, 2021). Digitalisation is applied by both large businesses and smaller businesses. From the view of smaller businesses, digitalisation gives opportunity to them to be more market-oriented with the use of new technologies. That is supported by Jin, Jung and Jeong (2018), who argue that the financial performance of smaller businesses is determined by market share, sales growth, and profitability. The businesses that have smaller capacities can perform better with stronger marketing capabilities.

The results of Jin, Jung and Jeong (2018) demonstrate that marketing capabilities help smaller businesses improve their financial performance and narrow their geographic emphasis (i.e., the scope of internationalisation), but they do not always ensure enhanced internationalisation (i.e., the proportion of foreign to total sales). For this reason, it is also argued that instead of focusing on the broad range of overseas markets, Korean businesses that are not large businesses but with marketing expertise are more likely to devote their limited marketing resources to a few key international markets because it is found that marketing capability has no influence on internalisation scale, adversely affected the volume of foreign markets that smaller businesses entered, however, have a positive influence on financial performance (Jin, Jung and Jeong, 2018).

Digitalisation, Marketing Capabilities, and International Business Performance

There is not enough research conducted in Turkey in that specific area to combine all these factors in the current literature. Bolel et al. (2017) had conducted a research on Turkish business that are actively trading in international markets. The main purposes of internalisation of nearly all these businesses are stated as profit and growth. Besides, foreign market opportunities, closeness to the foreign markets, unforeseen foreign orders, competitiveness, saturated internal markets, recognition, prestige, management desires and social reasons are mentioned as reasons for internalisation. Another research that covers digitalisation and globalisation was conducted by Şener, Savrul and Aydın (2014). They suggest that businesses should be able to use their resources more efficiently and increase their savings with the use of the Internet and comparable communication and information technologies. Without facing physical barriers and distance issues become less significant when businesses use digital technologies which allow them to access to the foreign markets in an easier way. This study also is lack of evaluating the concept from the perspective of international business performance and marketing capabilities in detail. The idea of digitalisation providing a competitive advantage to the company is highlighted by Balci (2021). The marketing capabilities are found as the second important source for the digital transformation. However, their influence on globalisation is not studied in this research. The marketing capabilities and international business performance was not mentioned previously.

The arguments mentioned above lead to the following hypothesis:

- H1. Digitalisation has a positive influence on marketing capabilities.
- H2. Digitalisation has a positive influence on the international business performance.
- H3. Marketing capabilities have a positive influence on the international business performance.

3. Methodology

This study explores how digitalisation and marketing capability affect a business's international business performance. The research is planned to be conducted on businesses in Turkey that make international activities like exporting. With the increasing globalisation of markets, digitalisation has become essential for businesses to be competitive in the international markets. However, the relationship between digitalisation, marketing capability, and international business performance, has been under researched. By performing an empirical examination of a sample of firms operating in Turkey, the study aims to fill this gap.

Participants and Research Model

In this study, the businesses expected to participate in the research were selected by convenience sampling method. The businesses expected to participate were tried to be reached online channels that can be interacted with, such as social media and e-mail. Forty-seven business representatives working at senior levels, such as marketing and management, participated in the study.

The study considers the relationships between digitalisation, marketing capabilities, exports, and market performance. It is argued that digitization affects marketing capabilities (i.e. Eller et al., 2020, Kohtamäki et al., 2020; Monteiro et al., 2017; Quarato, Pini and Positano, 2020), exports, and international market performance (i.e. Liu, Zhang-Zhang and Ghauri, 2020). It is also seen in the literature that marketing capabilities similarly affect exports and international market performance (i.e. Pham, Monkhouse and Barnes (2017). In line with this information, the research model is shown in Figure.1.

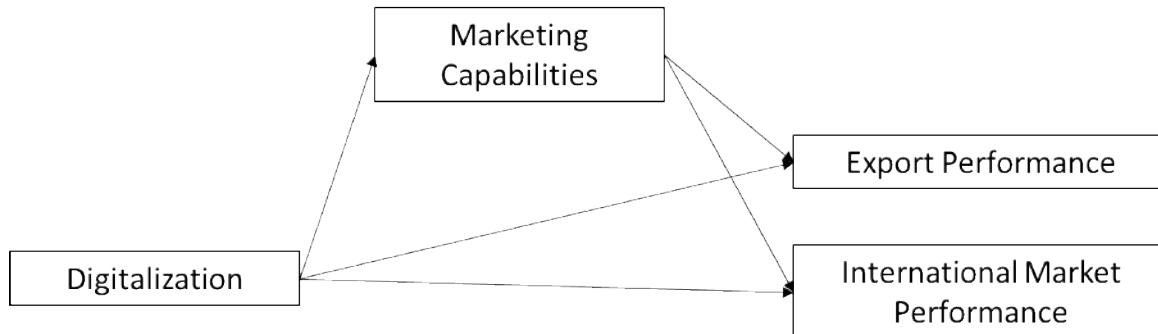


Figure 1.Research Model

Data Collection and Analysis

In the research, scales whose validity and reliability were provided in the literature were used. The statements used for digitalisation were adapted from Cassetta et al. (2020) and Joensuu-Salo et al. (2018), and the statements used to measure marketing capabilities were adapted from Vorhies et al. (1999). To assess international business performance, the statements used to measure export performance were adapted from Monteiro et al. (2017), and the statements used to measure international market performance were adapted from Liu et al. (2020). It was tested with 10 randomly selected business managers to test a structured questionnaire. The statements of export performance and international market performance in the model were arranged according to the 5-Likert Type. Measurements for marketing capabilities were made with 7-Likert Type. Finally, measurements for digitalisation were measured in binary form. The research also included questions to determine characteristics of businesses. Data were obtained through online structured questionnaires between 23.05-06.06.2023.

The small number of enterprises reached in the research makes it necessary to choose the data analysis within this framework. Partial Least Squares Structural Equation Modelling (PLS-SEM) analysis was preferred due to the importance of examining the relationships between variables in an integrated manner. PLS-SEM methodology provide accurate results at both high sample sizes and low sample sizes (Hair et al., 2019). In the study, Raw Graphs 2.0 was used for the showing demographic data and Smart PLS 4.0.9 analysis program was used to analyse the possible effects of variables.

4. Findings

Demographic Characteristics

According to the data (Fig.2), a total of 48 participants participated in the study. Most of the business (n=28) has more than 250 employees and operates in manufacturing (n=34). Also, most of the participants reside in Black Sea Region (n=16) and the vast majority have been operating for more than 16 years.

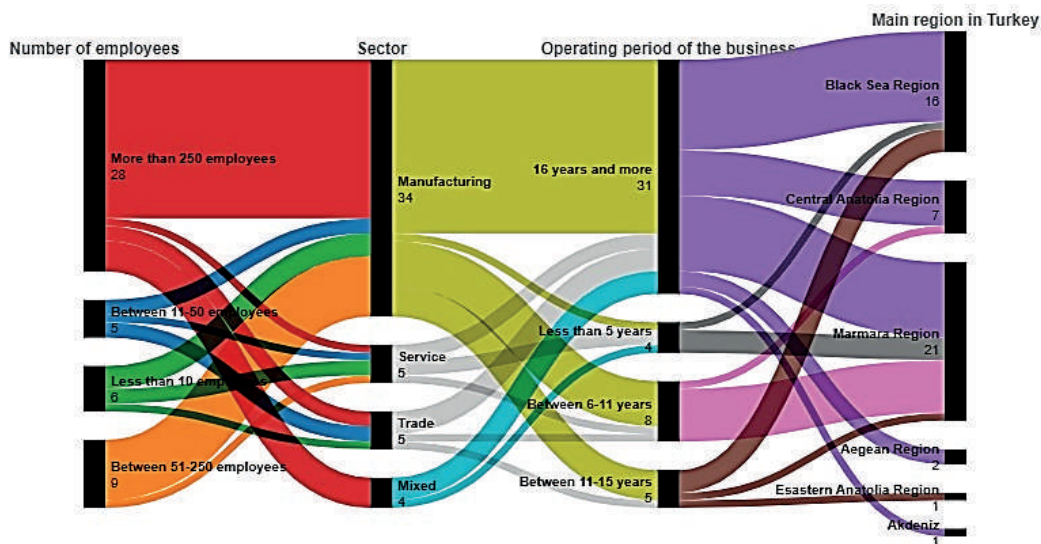


Figure 2. Demographic

Validity and Reliability Analysis

Before conducting PLS-SEM, it's crucial to check if the variables and indicators are suitable for analysis. In order to test for validity and reliability analysis, factor loadings, composite reliability values (CR), average variance extracted (AVE), and reliability values (Cronbach Alpha) are used.

According to the results of the validity and reliability analyses as shown in Table 1, it is seen that the factor loadings are greater than 0.7, the composite reliability values (CR) are within the expected intervals (0.70-0.95), the average variance extracted values (AVE) are at the required level (> 0.50), and the reliability values are high (Bagozzi & Yi, 1988; Chin, 1998; Hair Jr et al., 2016). According to these criteria, some items (Dg2, Pc1, Pc3, Pc4, Pm2, Imp3) were excluded from the analysis because they distorted the validity and reliability structure, had low factor loadings and, did not meet the VIF criteria. In line with these results, it was seen that all indicators and variables provide construct validity and reliability (Table 1).

Table 1. Structure Validity and Reliability Values

Constructs	Number of Items	Loadings	CR	Cronbach's Alpha	AVE	HTMT			
						1	2	3	4
1.Digitalisation	2	0.96-0.96	0.92	0.92	0.92				
2.Export Perf.	4	0.79-0.84	0.90	0.85	0.68	0.19			
3.Int. Market Perf.	2	0.90-0.93	0.82	0.81	0.84	0.33	0.61		
4.Marketing Cap.	4*	0.71-0.84	0.87	0.84	0.61	0.62	0.31	0.47	

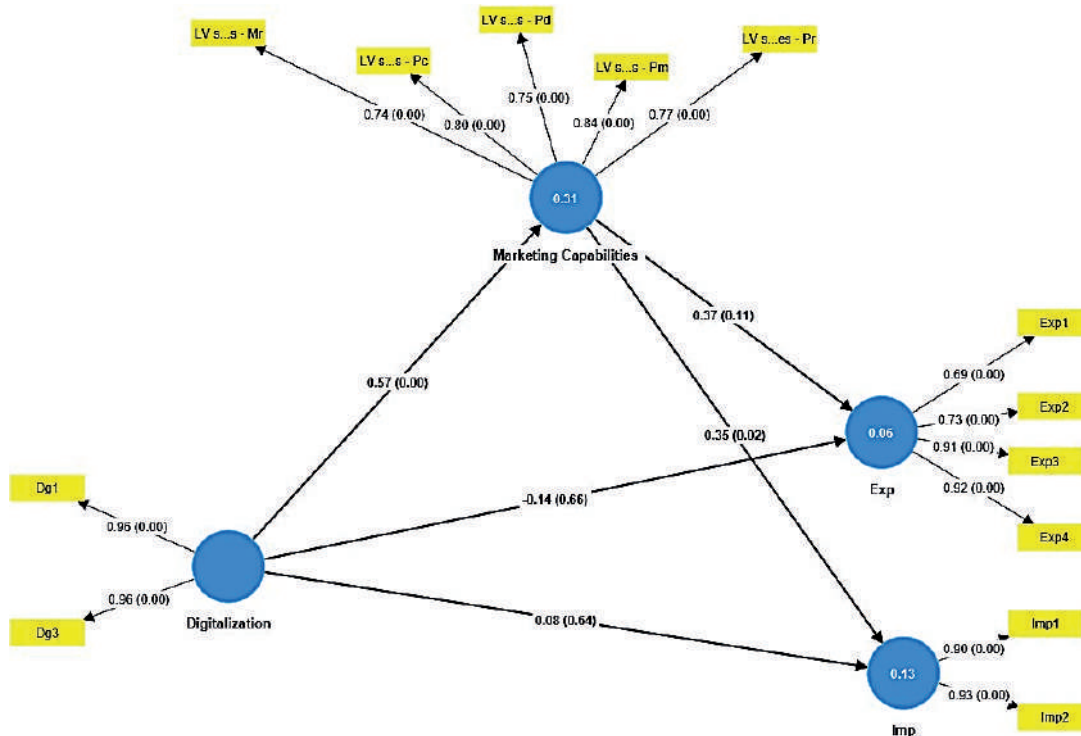
*Based on LSV (latent variable scores)

The Heterotrait-Monotrait (HTMT) values were examined to test the discriminant validity, showing that the construct was distinct and uncorrelated with other variables (Hair Jr et al., 2016). We see that the decomposition was achieved according to the HTMT criterion. The HTMT criterion is stated to be more inclusive, under some researchers (Voorhees et al., 2016). The findings support the claim that every variable in the research model offers discrimination validity.

Hypothesis Tests

The derivative sampling approach is used to raise the number of original samples to 1000 and test the relevance of the model's variables. The validity and reliability criteria, as well as the linearity ($VIF < 5$) and t values ($t > 1.96$) criteria, were all carefully checked before the study.

Figure 3. Hypothesis Tests



According to the results, digitalisation positively predicts marketing capabilities ($\beta=0.57$, $p=0.00$). However, digitalisation does not predict export performance ($\beta = -0.14$, $p = 0.66$) and international market performance ($\beta = 0.08$, $p = 0.64$). As another variable, marketing capabilities finds to be a predictor of international marketing performance as significant ($\beta= 0.35$, $p = 0.02$). However, marketing capabilities did not predict export performance significantly ($\beta= 0.37$, $p = 0.11$). Findings also revealed that 31% of the marketing capabilities, which is one of the dependent variables, are explained by digitalisation. Similarly, 06% of the export performance variable is explained by digitalisation. Finally, it was found that the variables of marketing capability explain the international market performance variable with %13. Accordingly, the H1 and H5 hypotheses are accepted, and the H2, H3, and H4 hypotheses are rejected. According to the results, it can be said that the research model is partially supported.

Table 3. Hypothesis Results

Hypotheses	β	Mean	T Statistics	P Values
H1. Digitalisation -> Export Performance	-0.14	-0.11	0.45	0.66 ^{n.s}
H2. Digitalisation -> International Market Performance	0.08	0.08	0.46	0.64 ^{n.s}
H3. Digitalisation -> Marketing Capabilities	0.57	0.58	5.74	0.00
H4. Marketing Capabilities -> Export Performance	0.37	0.35	1.59	0.11 ^{n.s}
H5. Marketing Capabilities -> International Market Performance	0.35	0.37	2.36	0.02

5. Discussion

In this study, the effects of the digitalisation on marketing capabilities, export performance, and international market performance were investigated. In addition, the effects of marketing capabilities on export performance and international market performance are also considered. It is expected to observe businesses that utilize digital technologies have better marketing capability, and businesses that utilize digital technologies with better marketing capability have a positive impact on international business performance.

According to the research findings, digitalisation positively predicts marketing capabilities. This situation is like the results of the studies conducted in the literature (i.e. Cassetta et al., 2020; Yu et al., 2017; Cenamor, Parida and Wincent, 2019; Kohtamäki et al., 2020, Monteiro, Soares and Rua, 2017; Eller et al., 2020; Cenamor, Parida and Wincent (2019) . Here, it can be argued that digitalisation has positively transformed marketing capabilities in enterprises. On the other hand, it can be said that the share of digitalisation has a very important place in the development of marketing capabilities with digitalisation ($B=0.57$). In addition, it is possible to mention that marketing capabilities are more dynamic from the perspective of digitalisation so that businesses can constantly update their capabilities with a digitalisation lens.

On the other hand, it was also observed that digitalisation did not positively effect export performance and international market performance. There are findings similar to this result in the literature (i.e. Joensuu-Salo et al., 2018). This result, which is contrary to the findings in the literature, may be due to the characteristics of the export market(s). The competitive conditions, structure, product characteristics, etc. of the markets may have limited the effects of digitalisation in these markets. In addition, the variability in exchange rates in the Turkish economy in recent years may also have had an impact on this result.

It is also among the findings that marketing capabilities have a positive effect on the international market performance of business. This result is in line with the results of the studies in the literature (i.e. Joensuu-Salo et al., 2018; Monteiro et al., 2017; Hao & Song, 2016; Jin et al., 2018). It can be said that marketing capabilities positively affect the performance of enterprises in the international markets in which they operate. This proves that market-related activities continue positively with marketing capabilities and that support market dynamics (such as share, entry, and sales). However, there was no proof that marketing capabilities had an impact on export performance. There are some findings similar to this result in the literature (i.e. Pham et al., 2017; Pinho & Prange, 2016) . This may be due to a combination of national factors such as economic instability, exchange rate instability, and global factors such as inflation increases, covid-19 pandemic, supply chain disruption, political instability, etc.

6. Conclusion and Limitations

Businesses encounter various challenges when they need a change. The current digitalisation trend provides lots of opportunities for businesses. However, utilizing digital solutions and products raises some concerns. This research produces empirical data that businesses can use. In line with the research results, it was found that digitalisation has an impact on marketing capabilities and marketing capabilities have an impact on international market performance. Although this situation demonstrates the crucial role of digitalisation in building business capabilities, it necessitates a re-examination of the topic with more in-depth study and data samples. However, the lack of a significant effect between digitalisation and international performance makes it inevitable to address it with new studies. Because digitalisation is known to be an important factor in internationalisation.

Finally, this study has various research limitations. In the research, it was quite difficult to reach many exporting enterprises from various sectors. For this reason, the findings should be compared with the results obtained from large samples. Similarly, the size of the enterprises may have limited their marketing capabilities and the effects of digitalisation on international performance. It may be necessary to ensure the consistency of the results of the study over enterprises with similar characteristics.

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DOES GREEN LEADERSHIP ORIENTATION ALWAYS DRIVE STRATEGIC PERFORMANCE IN AN EMERGING ECONOMY?

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Introduction

Environmental challenges have significant economic implications, costing the world trillions of dollars annually (Harvey, 2012). In Africa, these costs are projected to rise in the coming years (Watkiss et al., 2010). Human and corporate activities, including transportation operations, contribute substantially to these challenges, with emissions from the transportation sector being a major concern (Jayabalan et al., 2020). In Ghana, emissions from transportation and firms account for 70% of total emissions (Ayekor et al., 2021). As a result, there is increasing pressure from governments, non-governmental organisations, and society for organisations to adopt environmentally responsible practices (Iqbal, 2020). Given the global competitiveness and growing environmental concerns, the question arises: Can businesses in developing economies effectively foster organisation-wide environmental awareness and leverage these efforts to enhance their strategic performance?

Review of Relevant literature

Extant literature suggests that the success of corporate green programs relies on employees' voluntary participation and work attitude, as well as effective leadership (Paillé et al., 2014). Previous studies have highlighted the role of leadership in motivating subordinates and achieving organisational goals (Sadia and Aman, 2018). However, existing literature on corporate green/environmental initiatives has separately examined employees' green/environmental behaviour (Organisational Citizenship Behaviour for the Environment - OCBE) and the leadership orientation towards the environment. While antecedents of OCBE, such as green human resource management practices, transformational leadership, and green organisational identity, have been studied, OCBE outcomes have primarily focused on environmental or performance-related measures. Similarly, prior authors have studied the consequences of environmental orientation on both environmental performance, corporate financial and market performance. Very few authors explicitly studied leadership environmental orientation (Fatoki, 2019) in relation to non-environmental performance (Jiang et al., 2017).

Problem description

Previous studies on Organisational Citizenship Behaviour for the Environment (OCBE) have primarily focused on the family unit or private sphere practices, such as recycling or energy preservation in homes or hotels (Salvador and Burciaga, 2020; Tuan, 2019; Xiao, 2019). While these studies have provided valuable insights, it remains unclear whether the findings can be generalised to the work environment. Individuals nowadays spend a significant amount of time at their workplaces, where commercial and industrial activities have a greater environmental impact compared to domestic activities. Therefore, it is important to examine the relevance of emphasising OCBE in the work setting (Fatoki, 2019). Furthermore, despite the significant role played by the transportation and logistics sector in environmental discussions, the corporate environmental literature has predominantly focused on the manufacturing and hospitality industries, with limited insights from the transportation and logistics sector. These knowledge gaps necessitate further exploration of the specific challenges and opportunities related to OCBE in the transportation and logistics sector (Salvador & Burciaga, 2020; Tuan, 2019; Xiao, 2019).

The research work

In light of the issues pointed out, we draw inferences from the upper-echelons theory to argue that ‘green leadership orientation’ (GLO, hereafter) – the degree to which leaders recognise the significant impact humans and firms have on the natural environment and the need to minimise such impact (Banerjee, 2002)—will drive firm strategic performance through the ‘green citizenship behaviour’ (GCB, hereafter)—the extent to which individuals’ exhibit voluntary workplace behaviours that are not explicitly recognised by the formal reward framework but contribute to the effective green performance of the organisation (Paillé et al., 2014). Our basis for this argument is that workers’ commitment in GCB is essentially voluntary (Zhang et al., 2015). Therefore, leaders have the responsibility of imparting to workers the desired behaviour, culture, values, and norm necessary to achieve strategic goals, by serving as good examples (Wesselink et al., 2017). In a collectivist society like Ghana, where there is a significant power distance between leaders and workers, leaders hold considerable influence over their subordinates (Hofstede, 1984). In this context, it becomes crucial for managers to exhibit strong GLO, as it can drive GCB among employees and contribute to firm strategic performance. Building on institutional theory, we also argue that the indirect relationship between GLO and strategic performance through GCB is strengthened under high institutional pressures. The specific research questions the study seek to address are:

1. How does GLO relate with strategic performance?
2. Does GCB mediate the relationship between GLO and strategic performance?
3. Do institutional pressures moderate the proposed indirect relationship between GLO and strategic performance through GCB?

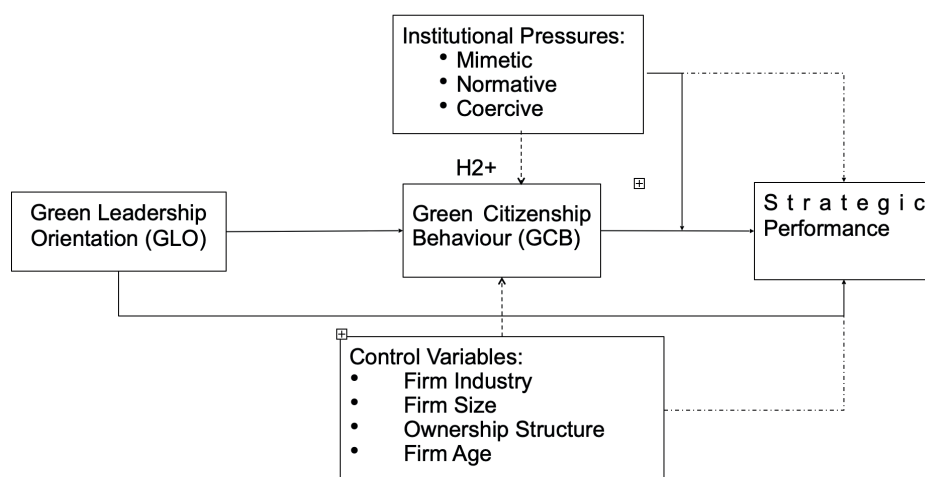


Figure 1: Conceptual framework

Results and analysis

To test our propositions, we collect data from 358 transportation and logistics firms in Ghana, a developing economy in the Sub-Saharan African region. Confirmatory factor analysis (CFA) was used to validate the measurement validity and reliability, for which the model fit indices was satisfactory: $\chi^2 = 362.892$; $df = 194$; $p = .000$; $\chi^2 / df = 1.87$; $TLI = .95$; $CFI = .96$; $RMSEA = .049$; $SRMR = .049$. For the structural analysis, we performed regression analysis using PROCESS macro version 4.0 plugin in IBM’s SPSS version 25, applying Module option 14. Three models were run to evaluate the hypotheses of the study.

Direct and interaction effects

In Table 1, Model 1 shows that GLO has a significant positive association with GCB ($\beta = .558$, $p < .001$). Similarly, GLO has a significant positive relationship with strategic performance ($\beta = .337$, $p < .001$), thus, providing support for H1. Surprisingly,

GCB has no significant association with strategic performance ($\beta = -.005, p > .05$). Mimetic pressure is found to have a direct significant positive relationship with strategic performance ($\beta = .195, p < .001$), whereas its interaction with GCB has no significant relationship with strategic performance ($\beta = .002, p > .05$). The results for Model 2 uniquely examine the direct effect of normative pressure and its interaction with GCB on strategic performance. The results reported shows that normative pressure has no significant relationship with strategic performance ($\beta = -.007, p > .05$). On the other hand, the interaction between normative pressure and GCB has a significant positive relationship with strategic performance ($\beta = .103, p < .05$). Model 3 uniquely examines the direct and interaction effect of coercive pressure on strategic performance. The results show that coercive pressure has not significant relationship with strategic performance ($\beta = .015, p > .05$). It's interaction with GCB, likewise, has no significant relationship with strategic performance ($\beta = -.013, p > .05$).

Variables	Model 1		Model 2		Model 3	
	GCB	StrPerf	GCB	StrPerf	GCB	StrPerf
Constant	-2.082*** (.345)	2.493*** (.470)	-2.056*** (.347)	1.563** (.494)	-2.010*** (.347)	1.677** (.496)
<i>Control Variables:</i>						
Firm size log	-.058 (.085)	.016 (.107)	-.076 (.087)	.003 (.106)	-.069 (.087)	.016 (.106)
Firm age log	.012 (.079)	-.042 (.098)	.001 (.080)	-.042 (.097)	.006 (.080)	-.044 (.098)
Manufacturing	.584*** (.048)	.404* (.158)	.581*** (.124)	.389* (.156)	.584*** (.124)	.404* (.157)
Locally owned	-.411*** (.116)	.086 (.146)	-.422*** (.115)	.065 (.144)	-.417*** (.116)	.088 (.145)
<i>Moderators:</i>						
Mimetic pressure		.195*** (.047)	-.036 (.037)	.198*** (.046)	-.025 (.036)	.195*** (.047)
Normative pressure	-.029 (.043)	-.044 (.054)		-.034 (.054)	-.014 (.042)	-.041 (.055)
Coercive pressure	.015 (.043)	.017 (.055)	.020 (.043)	-.007 (.055)		.015 (.055)
<i>Predictors:</i>						
Green leadership orientation	.558*** (.048)	.337*** (.072)	.566*** (.050)	.333*** (.072)	.574*** (.050)	.339*** (.072)
Green citizenship behaviour		-.005 (.067)		.012 (.065)		-.009 (.066)
<i>Interactions:</i>						
GCB*MP		.002 (.036)				
Variables						
	Model 1		Model 2		Model 3	
	GCB	StrPerf	GCB	StrPerf	GCB	StrPerf
GCB*NP				.103* (.040)		
GCB*CP						-.013 (.041)
CMV correction (negative affectivity)	-.115** (.036)	.095* (.045)	-.115** (.036)	.093* (.045)	-.113** (.036)	.095* (.045)

Model Fit:

R-square	.399	.238	.400	.252	.400	.238
R-square change		-.161	.162	-.148	.148	-.162
F-ratio	28.995	9.802	29.092	10.601	29.069	9.815
Df1	8	11	8	11	8	11
df2	349	346	349	346	349	346
P-value	.000	.000	.000	.000	.000	.000

Notes: c Mean-centered for respective interaction model; *, **, *** -- Significance at $p < .05$, $.01$, and $.001$, respectively at 2-tailed tests; Unstandardised coefficients are reported with standard error terms in parenthesis; StrPerf – Strategic Performance.

Table 1: Results for direct effects

Model		Relationship	Effect	BoostSE	95% Bootstrap CI	
					LLCI	ULCI
1	Direct Effects	GLO→GCB→StrPerf	-.002	.044	-.100	.081
	Conditional Indirect effect	GLO→GCB *MP→StrPerf	.001	.022	-.041	.047
2	Direct Effects	GLO→GCB→StrPerf	.019	.044	-.070	.103
	Conditional Indirect effect	GLO→GCB *NP→StrPerf	.058	.027	.011	.115
3	Direct Effects	GLO→GCB→StrPerf	-.005	.044	-.093	.080
	Conditional Indirect effect	GLO→GCB *CP→StrPerf	-.008	.025	-.054	.043

Note: StrPerf – Strategic Performance; GLO – Green Leadership Orientation; GCB – Green Citizenship Behaviour; MP – mimetic pressure; NP – normative pressure; CP – coercive pressure

Table 2: Indirect and Conditional Effects

Indirect and Conditional indirect effects

The results for the indirect effects were produced as additional results in PROCESS, with 95% bootstrap confidence interval (Table 2). We find that the indirect effect of GLO on strategic performance via GCB was not supported in either model – as the confidence intervals included zero “0” in each case, thus, providing no support for H2. Next, we find that mimetic pressure does not significantly condition the indirect relationship between GLO and strategic performance via GCB (Effect = .001, BootSE = .002, 95%BCI: -.041 to .047), thus, no support for H3a. On the other hand, normative pressure positively moderates the indirect relationship from GLO to strategic performance via GCB (Effect = .058, BootSE = .027, 95%BCI: .011 to .115), hence, supporting H3b. Finally, we find that the coercive pressure does not moderate the indirect effect from GLO to strategic performance via GCB (Effect = -.008, BootSE = .025, 95%BCI: -.054 to .043), thus, not supporting H3c.

Discussion and conclusion

Aligned with the Upper Echelons Theory, this study argues for a positive association between GLO and strategic performance. This proposition is supported by the empirical findings and aligns with previous research on various strategic orientations, such as entrepreneurial orientation and market orientation (Fatoki, 2019). The study makes a significant

contribution by expanding the scope of strategic orientation research, specifically by introducing the concept of “green leadership domain” as a crucial factor in enhancing firms’ strategic performance. By highlighting the instrumental relevance of GLO in fostering strategic performance, this study advances the literature on corporate green management and leadership beyond solely addressing environmental concerns in the context of developing economies (Hart, 1985).

The study employed the insights of both the UET and SLT to propose GCB as a mediating mechanism between GLO and strategic performance. Although GLO exhibited a significant relationship with GCB, contrary to our expectations, GCB did not show a significant association with strategic performance. Consequently, the indirect relationship between GLO and strategic performance through GCB was not supported. While previous studies have found GCB to mediate between Green Human Resource Management practices and environmental performance (Tariq et al., 2020), it is important to note that the relationship between managers’ environmental attitude, GCB, and performance is context-specific (Tariq et al., 2020), and contextual factors significantly influence firm performance (Burawat, 2019). Thus, failure to consider these contextual factors, whether internal or external to firms, may mask the proposed relationship. We address this with our overarching argument.

Our overarching argument is that the indirect relationship between GLO and strategic transport performance through GCB is strengthened under high institutional pressures. While we found no support for the moderating role of mimetic and coercive pressures, normative pressure exhibited a significant impact. Specifically, the indirect effect of GLO on strategic performance through GCB is significant under various conditions of normative pressure. Notably, our further analysis revealed that this interaction effect holds true across all levels of normative pressure. This reinforces the point that contextual factors can influence the performance outcomes of corporate green initiatives (Burawat, 2019). Importantly, this finding emphasises the significance of institutional theory by illustrating that in contexts characterised by weak formal regulatory and industry/market forces, normative pressure from the informal sector becomes pivotal in driving the strategic performance outcomes of GLO through GCB. That is, in contexts where formal institutions struggle to enforce desired behaviours, normative pressure from informal institutions fills the void (Webb et al., 2020).

Managerial implications

Firstly, this study highlights that managers should lead by example if they can influence green behaviour of followers (employees). Leaders must actively and intentionally influence employees to adopt green orientation by creating a supportive work environment and fostering a culture that encourages green behaviours.

Secondly, managers should recognise that corporate-wide green practices may not always have as direct an impact on strategic performance as leaders’ green orientation. However, when faced with high levels of normative pressure, firms can expect to reap benefits from their green initiatives. Managers operating in collectivist developing economies, where formal institutional pressures may be weaker, should pay particular attention to the emphasis on the environment by the informal sector in order to achieve superior strategic performance.

Policy implications

Policies should target corporate leadership in Africa to promote green orientation and behaviour, in the effort towards contributing to climate decarbonisation. Also, environmental policy makers in Africa can capitalise on the influential role of the informal sector to drive corporate green investment. This could be achieved by increasing environmental/climate awareness among the people through formal and informal educational programmes, in order to re-orient their worldview, and consequently, their cultural values about the environment in every aspect of their lives.

Limitations and avenues for future studies

The use of cross-sectional data restricts causal inferences, and while a longitudinal design is preferable. Future research is strongly advised to employ longitudinal data for a re-evaluation of the model. The study focused on institutional pressures as boundary conditioning factors, but other internal and external firm resources and capabilities – such as digitisation and modern technology – warrant exploration in relation to the link between green organisational behaviour variables and performance outcomes. Future studies are encouraged to examine this structure-context fit further enrich the theoretical understanding in this domain of research.

Conclusion

This study aimed to address the lack of theoretical and empirical development regarding the link between organisational green behaviour initiatives and firm strategic performance in the transportation operations sector. Drawing on the Upper Echelons Theory and Social Learning Theory, we introduced the concept of GLO as a determinant of strategic performance and GCB as a catalyst, under the boundary conditioning influence of institutional pressures. Using data from transportation operations of firms in Ghana, a collectivist cultural context, this study expands the literature on corporate green and leadership literature by demonstrating the direct impact of GLO on GCB and firms' strategic performance. Additionally, it reveals that the indirect effect of GLO on strategic performance through GCB is realised under high normative pressure. By exploring the mechanism and conditions in which green behavioural variables contribute to strategic performance, this study deviates from the typical focus on GLO, GCB, and environmental performance. The findings offer valuable insights for green transport leadership and policy in Africa, while also paving the way for future research.

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EVALUATING THE BLOCKCHAIN-BASED E-PROCUREMENT SYSTEM: A SYSTEMATIC LITERATURE REVIEW AND FUTURE RESEARCH DIRECTIONS

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1. Introduction

Blockchain technology can track products from their source to the end consumer (Nandi et al., 2021). This can help businesses to ensure that their products are produced and transported in an environmentally sustainable way (Cho et al., 2021; Nandi et al., 2021). Blockchain-based system track and monitor the environmental impact of supply chain activities (Saber et al., 2019). For example, companies can use blockchain technology to track the carbon footprint of their supply chain activities and take steps to reduce their environmental impact, also ensuring that products are sourced ethically and sustainably (Carminati et al., 2018). Thus, it will not be wrong to suggest that blockchain is an emerging technology that can bring transparency and efficiency to the development sector (Bhatt et al., 2021). In combination, blockchain can help businesses to stimulate their operations and improve their procurement processes. Businesses can reduce operational costs and time of the procurement process. At the same time, this combination will help them identify areas for improvement, leading to greater operational efficiency and cost saving. This way, businesses may be able to sustain themselves in the rapidly changing business environment (Shatta, Shayo & Layaa, 2020).

Various papers have been written about blockchain, but there are still research gaps around how this innovative technology is applied to e-procurement (Mavidis & Folinas, 2022). This motivated the researchers to conduct a study evaluating the blockchain-based system for e-procurement. It won't be wrong to say that blockchain has not been examined comprehensively as a benchmark for efficient e-procurement. Blockchain technology can potentially provide solutions for some of the challenges associated with e-procurement. However, it is important to note that blockchain technology is not a panacea and that there may be limitations and trade-offs associated with its use in e-procurement. Thus, the basic aim of the current review is to carefully evaluate blockchain technology's potential benefits in e-procurement processes.

Research Questions: How does blockchain supports e-procurement?

To achieve answers to the above-mentioned research question, the current review identified several benefits of blockchain-based e-procurement systems, including enhanced transparency, security, and efficiency.

The following review is structured as follows: the first section outlines an introduction and the motivation behind the topic. At the same time, the second section explains the adopted methodology leading to the third section that presents the literature review about blockchain and e-procurement. Later, the fourth section presents the findings and discussion on the research outcome, and finally, the fifth section presents the conclusion along with a few research directions for future researchers.

2. Methodology

The current study presents an SLR on the alignment between blockchain technology and its role in e-procurement. It is an evidence-based approach that identifies the current and progressing knowledge using secondary data from a relevant field of interest. Knowing how the relationship among key constituents (blockchain technology and e-procurement) occurs is viable, especially the related circumstances to conclude their harmony. There are four steps followed by the authors:

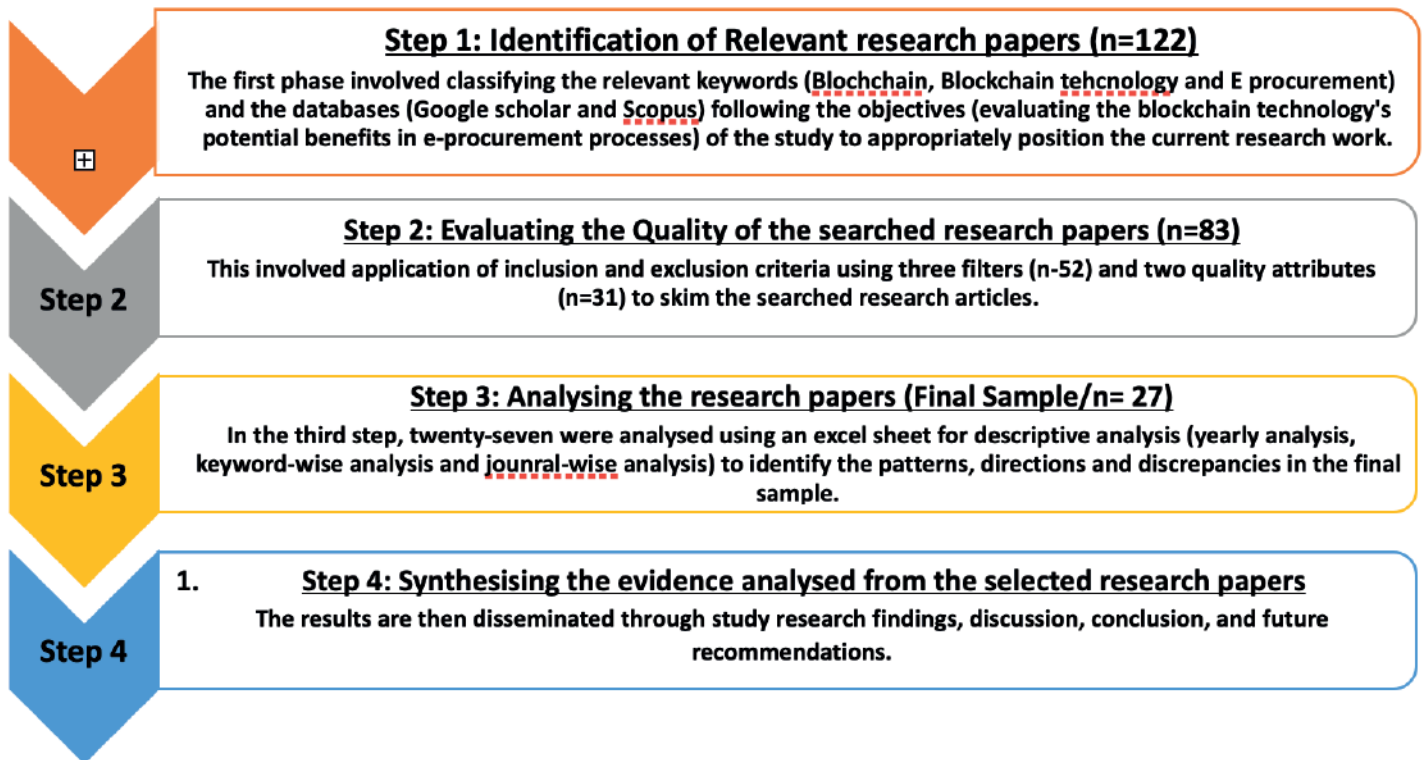


Figure 1: Steps of SLR

2.1. Step 1: Identification of Relevant research papers

The first phase involved classifying the relevant keywords following the objectives (evaluating the blockchain technology's potential benefits in e-procurement processes) of the study to appropriately position the current research work. After extensive consideration, three keywords related to the research domain were finalised that met the screening criteria, i.e., blockchain, blockchain technology, e-procurement. These keywords were later refined and put into combinations by using Boolean logic, "blockchain and/or e-procurement," "blockchain technology and/or e-procurement,". At the end of this step, one hundred and twenty-two papers (122) were identified from the two databases (Google Scholar and Scopus). The authors decided to use these two databases because the papers are easily accessible here, specifically because Scopus automatically includes the papers from Wiley, Emerald insight, and Taylor & Francis.

2.2. Step 2: Evaluating the Quality of the searched research papers

In the second step of SLR, the researchers deleted the 12 research papers because they were duplicated. Later the authors decided to apply inclusion and exclusion criteria that are presented in table 1. These criteria were applied to the sample to analyse the research papers in a structured way which are as follows:

Table 1: Inclusion and Exclusion criteria

Inclusion Criteria		Exclusion Criteria	
Filter 1: Time Span			
The research papers published during 2017-2022 will be included		The research papers published outside the selected window of 2017-2022 will be excluded n= 14	
Justification: Industry 4.0 was introduced in 2016, and after that, only the adoption of blockchain and e-procurement measures were introduced.			
Filter 2: Language			
Research papers that are written and published in English language only will be included		Research papers written and published in any other language except for English will be excluded n=17	
Justification: English is the dominant language of scientific communication spoken worldwide. Therefore, it is set to use English research papers to main the standardised parameters.			
Filter 3: Academic Discipline			
The papers that were written from business management perspective will be included		The papers that were not written from business management perspective were excluded n=21	
Justification: Most of the Blockchain-related literature was written in engineering. At the same time, the authors decided to include the papers written from a business management perspective because they are more likely to provide insights specifically relevant to business management.			

Later, to validate the quality of evidence, the researchers set two quality attributes (presented in table 2) to maintain the transparency, inclusivity, explanatory, and heuristic nature of the sample size which were:

Table 2: Quality Attributes

Quality Attributes (QA)
QA1: Do the selected papers discuss mix of the keywords (blockchain, blockchain technology and e-procurement)? n = 19
QA2: Does the selected paper presents the findings, results, and conclusion that corresponds to our research domain? n = 12

At the end of step two, the researchers managed to finalise twenty-seven (27) research papers used in the analysis.

2.3. Step 3: Analysing the research papers

In the third step, twenty-seven were analysed using an excel sheet for descriptive analysis to identify the patterns, directions, and discrepancies in the final sample.

2.4. Step 4: Synthesising the evidence analysed from the selected research papers

In the fourth step, the researchers synthesise the descriptive analysis, giving a set of classifications for various data attributes. The results are then disseminated through study research findings, discussion, conclusion, and future recommendations.

3. Literature Review

3.1. Blockchain

Blockchain is a distributed ledger technology that allows for secure, transparent, and tamper-proof record-keeping of transactions (Bellucci et al., 2022; Cho et al., 2021). It is a decentralized database maintained by a network of computers rather than a central authority (Carminati et al., 2018). Each block in a blockchain contains a set of transactions that are verified and recorded by a network of computers called nodes. Once a block is added to the chain, it cannot be altered or deleted, ensuring the data's integrity and immutability (Karamchandani et al., 2021). Blockchain technology is most associated with cryptocurrencies like Bitcoin, but it has many other potential applications, such as supply chain management, voting systems, and digital identity verification. Blockchain technology has the potential to transform logistics by increasing transparency, traceability, and efficiency while also improving collaboration and security (Fernando et al., 2022; Teisserenc & Sepasgozar, 2021). By leveraging the benefits of blockchain technology, logistics companies can optimize their operations, reduce costs, and deliver better service to their customers (Rupa et al., 2021a; Saberi et al., 2019).

3.2. E-procurement

E-procurement, also known as electronic procurement, purchases goods and services online using electronic platforms and technologies (Bag et al., 2020). It involves using internet-based software and tools to manage the procurement process, from supplier selection and bidding to order management and payment (Jafari et al., 2022). E-procurement can help organizations to reduce costs by improving the efficiency of the procurement process, negotiating better prices with suppliers, and reducing the risk of fraud and errors (Okorie et al., 2022). E-procurement can include various technologies, such as online marketplaces, e-catalogues, reverse auctions, and electronic data interchange (EDI) (Larivière and Smit, 2022). Both public and private sector organizations can use it to streamline procurement processes, increase efficiency, reduce costs, and improve supplier management (Pattanayak & Punyatoya, 2020; de Moraes et al., 2022). E-procurement's key benefits of e-procurement include Increased efficiency: E-procurement can automate many of the manual tasks involved in the procurement process, such as creating purchase orders and processing invoices, which can help reduce errors and save time. Improved supplier management: E-procurement provides a centralized platform for managing supplier relationships and monitoring supplier performance, which can help organizations to make better-informed decisions about supplier selection and contract management (Bag et al., 2020; Shatta, Shayo, & Layaa, 2020). E-procurement can provide greater visibility into the procurement process, allowing stakeholders to track transactions and monitor compliance with procurement policies and regulations. Overall, e-procurement can be a valuable tool for organizations looking to streamline their procurement processes, reduce costs, and improve supplier management.

3.3. Blockchain-based E-procurement

Rupa, et al. (2021a) insist that blockchain technology plays a vital role in designing and arrangement of various real-time applications (Rupa et al., 2021a). Companies can anticipate and understand their devices (status and constraints) and their premises; simulate potential situations and estimate the impact of changes in the value chain outlet on the rest of the organisation. On the other hand, the data that is composed during the manufacturing cycle with continuous implication of smart devices, meters, and sensors throughout the entire manufacturing cycle of product and process, can be used for assessment of associated costs and overheads (Huang et al., 2013); investigating the cost-drivers, enhancing the efficacy of operations as well as for setting pricing or other decision-making (Wang and Yue, 2017). Blockchain technology is a disruptive technology. Currently, so many real-time applications are being designed using this advanced mechanism. As per Al Nuaimi et al. (2021), utilizing electronic information channels for procurement tasks, including seeking, buying, and vendor selection, is called e-procurement. Effortless internet shopping portals to sophisticated, comprehensive procurement processes with capabilities like digital inventories, supplier evaluation, and contractual relationships are all e-procurement processes. Ahmed et al. (2019) stated that the e-procurement system accelerates federal programs and increases service delivery. Providers can partake in the procurement activities provided by public entities. Bureaucracy's old 'manual procurement procedure' is replaced with electronic-based procurement through the Online platform. Likewise, Rupa et al. (2021b) conducted a study on health-care centre and proposed a system that employs blockchain application in a user expert system as a knowledge agent.

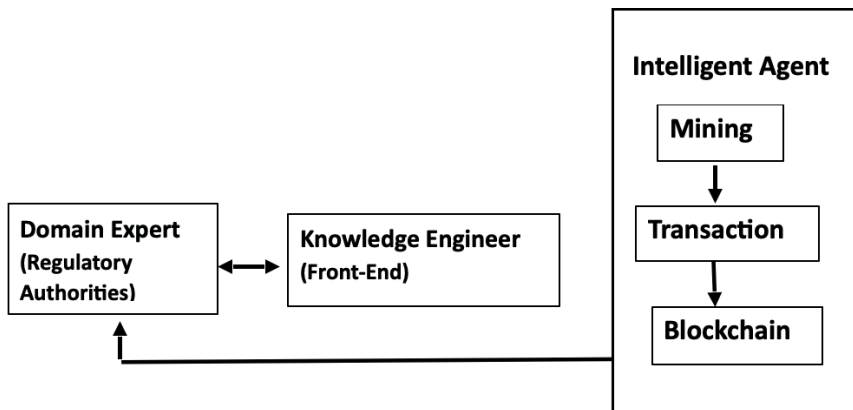


Figure 1. Blockchain based E-procurement System

In the following system, the regulatory authorities grant permission to the knowledge engineers for generating and issuing the medical certificate by providing them (health care centre) a unique id. Later it demonstrates the operations being performed over a blockchain network. After verification of data, the database creates a blockchain-based ID. This way only the authorised person could enter the application (Rupa et al., 2021b).

4. Findings and Discussion

4.1. Descriptive Analysis

4.1.1. Yearly Analysis

The yearly Analysis helped the researchers to track how blockchain technology-based e-procurement-related studies have evolved during the selected time span i.e., 2017-2022.

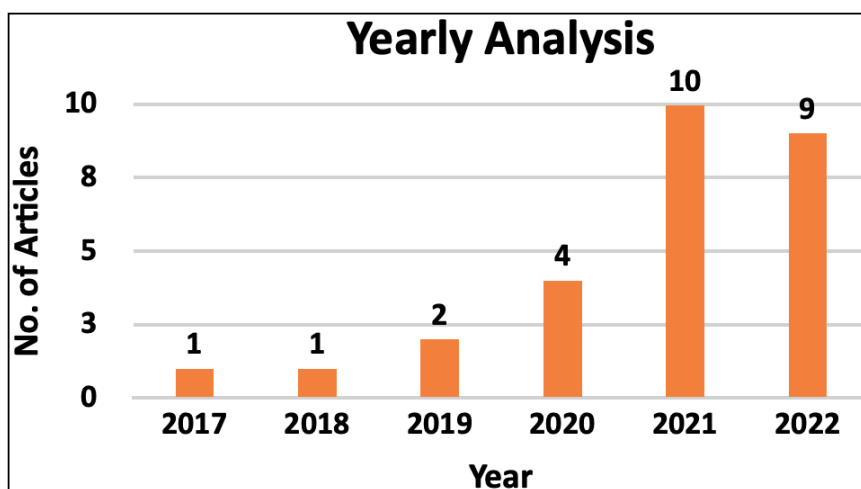


Figure 2: Yearly Analysis

Figure 2 presents the yearly analysis of the sample of the current study. It is evident from the bar chart that blockchain technology-based e-procurement-related literature has gained extra attention from researchers and practitioners after 2019. The reason could be linked to the popularity of industry 4.0 technologies (blockchain) during the Covid-19 period, where societies relied a lot on technology to comply with their work-related and daily tasks.

4.1.2.Keyword Analysis

The researchers have conducted a keyword wise analysis for the current study to identify the patterns and links in sample.



Figure 3: Keyword Analysis

Figure 3 presents the keyword-wise analysis. It is noted that supply chain, blockchain, decentralised and system are among the keywords widely used in the sample. The most common theme among the sample is related to the system and network management, while the second popular theme is risk detection and real-world issues.

4.1.3.Journal-wise Analysis

Researchers are based in different countries and researching various aspects of a phenomenon from different academic disciplines. As previously established in the methodology, the current study's researchers set two quality attributes. They decided to use the research papers corresponding to the business management domain. Therefore, a journal wise analysis was conducted to verify the sample's relevance to the business management academic discipline and validate the research output's quality.

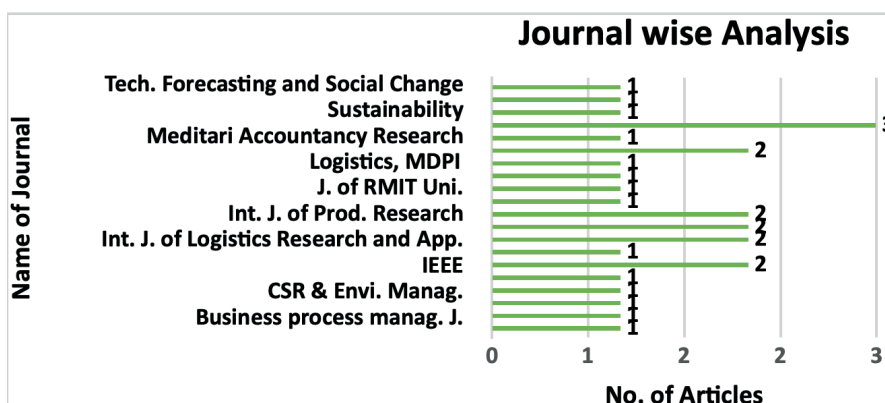


Figure 4: Journal-wise Analysis

Figure 4 presents the key journals in the research domain within the pre-decided timespan (2017-2022), highlighting the most relevant papers based on blockchain technology and e-procurement. Although a few papers were used from mathematical bioscience (Rupa et al., 2021a; Rupa et al., 2021b) and engineering healthcare journal (Li et al., 2021), the reason for that is that paper was written from a business management perspective. It was important for researchers of the current study to use some papers from applied science because these papers helped the authors to analyse the link between blockchain technology-based systems. However, most other papers are mostly extracted from business study-related journals because it was important for the researchers to analyse the blockchain-based system integration from the e-procurement's stance.

4.2. Thematic Analysis

The current study has focused on evaluating the potentials of blockchain from e-procurement aspect. Therefore, two themes have been identified to evaluate the benefits of blockchain-based e-procurement which are as follows:

4.2.1. Theme 1: Improving Transparency and Security

In today's business environment, organisations face the challenge of managing major data related challenges to gain momentum for increased productivity (Frank et al., 2019; Nandi et al., 2021). To find solution to these issues, blockchain will provide a platform, where data-sharing can be done on miners (that are also called where nodes) by algorithms to validate the submitted data (Bellucci et al., 2022; Cho et al., 2021). Many production systems are training their employees to track the big data through smart devices. Hence, an online availability and sharing across the supply chain of multiple users is essential that should be secured by a unique digital signature (Carminati et al., 2018; Rupa et al., 2021a; Saberi et al., 2019). Most of the researchers are suggesting that blockchain technology is considered as a secured digital ledger that can be used for generating and tracking the data. It comes in various forms depending on individual's objective, but the outcome extracted is instantaneous and transparent (Fernando et al., 2022; Karamchandani et al., 2021; Okorie et al., 2022).

4.2.2. Theme 2: Risk Detection

Another popular theme that many of the researcher's focus is the application of machine learning and blockchain technology (Li et al., 2021). The researchers believed that blockchain is aiding in resource conservation and risk detection in sustainable supply chain management (Esmailian et al., 2020). The firm environment is characterised by unstructured data that pose high level of uncertainty. Thus, the ambiguity adds the element of risk in executive decisions (Bai et al., 2021). Therefore, the blockchain technology can be used to detect risks that have occurred previously in various manufacturing activities in the industry and is more likely to evaluate new questions that emerge as well as the various answers to prevent their recurrence in the industry (Okorie et al., 2022).

4.3. Discussion

It is evident from the review of the current study that most of the studies are consenting that blockchain as a highly secured technology for resilience. Therefore, it won't be wrong to declare that businesses need to rethink the concept of e-procurement system in due course and adopt the blockchain-based system to improve the transparency and security of the supply chain alignment. Much research from the sample is focused on the automation stance of e-procurement, suggesting that automation elaborates the chances of reducing the extortionate labour costs from the production; the designing stage, followed by development phase and finally the production cycles. Hence, the data collected at various stages of a product's lifecycle (i.e., from production to consumption) is used to uncover the useful information for management of operations at different phases of production (Prieto-Sandoval et al., 2019). Furthermore, blockchain is also well-discussed among researchers for providing smart contract programmability. Pre-set rules and regulations are agreed upon/signed among the key partners that aid in the programming and settlement of accounts and transactions to support the payment system. This programmed system automatically tracks the authentication of payment and authenticates the transaction, preventing any means of prudery activity. Thus, blockchain technology helps in developing a reputation system among the actors instead of having a monopolistic provider monitoring the interactions. Overall, blockchain technology can be a valuable tool for businesses looking to maintain a sustainable supply chain. By providing transparency, traceability, and accountability, blockchain technology can help businesses to identify and address sustainability issues throughout the supply chain and work collaboratively with supply chain partners to achieve sustainability goals.

5. Conclusion

Blockchain maintains transparency through a secure and decentralised platform for all the stakeholders that help prevent fraudulent activities and errors in the procurement process. Blockchain-based e-procurement systems have garnered significant attention recently due to their potential to enhance transparency, security, and efficiency in procurement processes. A systematic literature review was conducted to evaluate the existing research on blockchain-based e-procurement systems and identify future research directions. It has been concluded from the current review that

blockchain technology can improve transparency by providing a secure and tamper-proof record of all procurement activities. It can enhance security by preventing fraud and ensuring only authorized personnel can access procurement records. It can also improve efficiency by automating procurement processes and reducing the need for intermediaries.

6. Future Research Directions

Following are a few recommendations for future researchers:

6.1. Exploring the challenges of blockchain based system

In conclusion, blockchain-based e-procurement systems have the potential to enhance transparency, security, and efficiency in procurement processes. However, several challenges still need to be addressed, and more research is needed to evaluate the effectiveness of these systems and identify ways to improve them. It will be interesting to see how future researchers will attempt to identify challenges associated with blockchain-based e-procurement systems, including scalability, interoperability, and regulatory issues. Scalability remains a significant challenge and interoperability is also an issue, as different blockchain platforms may not be compatible. Regulatory issues, such as data privacy and security, must be addressed.

6.2. Potential topics for Empirical Studies

There is also a lack of empirical studies that evaluate the effectiveness of blockchain-based e-procurement systems in real-world settings. Thus, some potential research ideas for future researchers could be conducting empirical studies to evaluate the effectiveness of blockchain-based e-procurement systems in real-world settings. Moreover, developing interoperability standards to enable different blockchain platforms to communicate with each other could also be a potential research area.

6.3. Evaluating blockchain with other Industry 4.0 technologies

Furthermore, addressing regulatory issues related to data privacy and security and exploring the potential of integrating blockchain technology with other emerging technologies, such as artificial intelligence and the Internet of Things, could be another potential research area.

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EXPLORING SUSTAINABLE HORIZONTAL COLLABORATION IN URBAN LAST-MILE LOGISTICS: AN INITIAL FRAMEWORK FOR ENHANCING COMPETITIVE ADVANTAGE IN THE UK

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This study explores the potential of horizontal collaboration (HC) in urban last-mile logistics (LML) to enhance sustainability and competitiveness amidst the rapid growth of e-commerce and urbanisation. Through a comprehensive literature review and a plan to undertake semi-structured interviews with logistics professionals, the research identifies key drivers, strategies, and challenges of HC. Theoretical lenses of Transaction Cost Economics and the Resource-Based View are used to understand the benefits of HC, including reduced transaction costs and enhanced competitiveness through resource synergy. The study aims to develop an initial sustainable theoretical framework for HC in LML, contributing to improved sustainability outcomes and increased competitiveness in urban last-mile delivery.

1. Introduction

The emergence of e-commerce resulting in the surge in urbanisation have exerted significant pressure on last-mile logistics (LML), presenting challenges in achieving sustainability goals and maintaining a competitive edge (Morganti et al., 2014). The last-mile, defined as the final leg of the supply chain where goods are delivered to the end consumer, is a critical component of the logistics process (Halldorsson & Wehner, 2020; Savelsbergh & Van Woensel, 2016). It is also the most costly part of the supply chain, accounting for up to 28% of the total cost to move goods (Morganti et al., 2014). This cost is accompanied by the complexity exacerbated by the rapid growth of e-commerce, leading to an increase in the volume of goods delivered and the frequency of deliveries, thus increasing the environmental impact and operational costs associated with LML.

In response to these challenges, there has been a growing interest in exploring innovative strategies to improve the efficiency and sustainability of LML. One such strategy is horizontal collaboration

(HC), which involves companies at the same level of the supply chain working together to achieve common objectives (Crujssen et al., 2007; Shoeder et al., 2016). HC has been recognised as a potential solution to the challenges faced by LML, as it can lead to improved operational efficiency, reduced costs, and enhanced environmental sustainability (Gonzalez-Feliu et al., 2013; Ballantyne et al., 2013).

This paper aims to explore the potential of HC in urban LML within the context of the UK. It seeks to identify the key drivers, strategies, and challenges associated with HC and examine its overall impact on sustainability and competitiveness. The research is based on a literature search undertaken as part of PhD thesis and builds on existing literature and combines them with various relevant theoretical lenses to paint a clearer understanding of advantages relating to HC in LML. It was also focused on answering the following research questions: 1. What is the current outlook on HC in LML? 2. What are the main drivers for HC in LML? 3. What are the key strategies used, and which of them work best? 4. What are the challenges for HC in LML? 5. What are the existing gaps, and what is the best approach to building a comprehensive framework?"

"In the future, a qualitative approach, involving semi-structured interviews with professionals in the logistics sector is planned to complete the PhD thesis. The findings are expected to contribute to the development of a comprehensive framework for sustainable HC in urban LML.

The paper is structured as follows. Section 2 provides a review of the literature on HC, LML, and sustainability. Section 3 outlines the research methodology, including the data collection and analysis methods. Section 4 presents the findings and discussion. Section 5 presents the initial proposed theoretical framework prior to the interviews for sustainable HC in urban LML and section 6 concludes the paper and provides directions for future research.

2. Literature Review

The literature on HC in LML and sustainability is extensive, reflecting the complexity of these concepts and their interrelationships.

Morganti et al. (2014) were among the first to highlight the challenges of meeting sustainability goals in the context of the rapid growth of e-commerce and urbanisation. They emphasised the pressure these factors exert on LML. Their work set the stage for the exploration of potential solutions such as HC. Cruijssen et al. (2007) and Schoeder et al. (2016) further delved into the potential of HC in urban LML. Their research identified key drivers, strategies, and challenges of such collaborative practices. They found that HC can lead to cost savings, improved service levels, and increased flexibility, thereby enhancing both sustainability and competitiveness. They also mentioned that the barriers to HC are experienced by both companies that participate in HC and companies that don't.

Gonzalez-Feliu et al. (2013) and Ballantyne et al. (2013) expanded on these insights, examining the overall impact of HC on sustainability and competitiveness. They stressed the potential benefits of HC, including reduced transaction costs and enhanced competitiveness through resource synergy. Their work highlighted the importance of HC in achieving sustainable logistics operations.

McKinnon (2013) and Soysal et al. (2012) contributed to the literature by conducting reviews of studies related to HC, LML, and sustainability. Their work synthesised the current state of knowledge in the field, providing a solid foundation for further research. They identified gaps in the literature and proposed directions for future research, emphasising the need for empirical studies to validate theoretical findings.

Macharis et al. (2014) and Papadopoulou et al. (1998) focused on the methodological aspects of research in this area. They advocated for the use of qualitative approaches, such as semi-structured interviews, to gain deeper insights into the experiences and perspectives of professionals in the logistics sector. They argued that such approaches can provide rich, context-specific data that can enhance our understanding of the complexities and nuances of HC in LML.

Gansterer and Hartl (2017) provided a survey based around the concept of HC, specifically collaborative vehicle routing, a key aspect of HC in LML. Their work highlighted the benefits of HC in improving routing efficiency and reducing environmental impact. They argued that collaborative vehicle routing can lead to significant cost savings, reduced carbon emissions, and improved service levels, thereby contributing to the sustainability and competitiveness of logistics operations.

Adetiloye and Awasthi (2023) emphasised the importance of stakeholder collaboration in achieving sustainable city logistics operations. They argued that effective planning and coordination among various stakeholders, including logistics service providers, customers, and government agencies, are crucial for the success of HC initiatives. They also highlighted the role of information sharing and trust in facilitating effective collaboration."

"Schlicher and Lurkin (2022) explored the economic aspects of HC, focusing on collaborative price setting. Their research demonstrated the potential of HC in enhancing competitiveness and market performance. They found that collaborative price setting can lead to more competitive prices, benefiting both logistics service providers and their customers.

Kayikci (2018) explores the impact of digitisation on logistics and supply chain management. She highlights the benefits of digitisation, such as real-time transparency, small lot sizes, multiple product variants, connected processes, and decentralised, autonomous management. This work is relevant as it points to the potential of digital technologies in enhancing HC and improving the sustainability of LML.

Verlinde, Macharis, and Witlox (2012) discuss the concept of urban consolidation centres as a measure to reduce the number of motorised freight vehicles in cities. They highlight the challenges associated with these centres, such as their reliance on government subsidies, and suggest alternative consolidation strategies. This work is relevant as it explores innovative solutions to the challenges of urban LML, which can inform the development of sustainable HC practices.

Finally, Miao (2022) addressed the issue of data privacy in HC. His work on privacy-preserving logistic regression for horizontally distributed data highlighted the need to balance data utility and privacy in collaborative learning, a concern that is particularly relevant in the context of digitalised logistics operations. He proposed a privacy-preserving algorithm that allows logistics companies to collaborate in a secure and efficient manner.

The absence of a comprehensive framework is a significant limitation in the current literature. Such a framework would provide a structured approach to understanding and enhancing competitive advantage, allowing for a more systematic analysis and implementation of strategies. It would also help identify and manage drivers and challenges, thereby improving the effectiveness of competitive advantage initiatives.

3. Methodology

The methodology for this study was designed to ensure a comprehensive and rigorous approach to the literature review. The process was divided into seven steps, as outlined below:

1. Formulation of Research Questions

The first step involved the development of clear research questions based on identifying and understanding strategies, drivers, and challenges related to HC in LML. The research questions were carefully crafted and mentioned in the introduction section of the review, considering the existing gaps in the literature and the specific objectives of the review.

2. Literature Search

A comprehensive search of relevant literature was conducted using appropriate databases and search terms. The databases chosen for this search included ScienceDirect, Scopus, Web of Science (WoS), DOAJ (Directory of Open Access Journals), IEEE Xplore and TRID (Transport Research International Documentation). The search terms were selected to be as comprehensive as possible, focusing on the main topic of the review.

3. Screening of Studies

The identified studies were screened based on inclusion and exclusion criteria. Papers were included if they were peer-reviewed journals, government-level reports and book chapters to

“focus on the highest quality articles and take a wide variety of literature. Papers that focus on horizontal or vertical collaboration were considered in order to benefit from some of the advantages that vertical collaboration may bring. Finally, papers that focused on HC in Urban LML were taken and not rural since rural LML poses a geographically significantly different challenge. As for exclusion, papers that did not discuss collaboration and those that were not English were not omitted. This involved removing duplicates, screening titles and abstracts for relevance, removing irrelevant journals, and reviewing the full papers.

4. Data Extraction

Relevant data from the included studies were extracted. This included the title, abstract, keywords, author's names, journal name, and year of publication. The data was extracted to an MS Excel spreadsheet for the purpose of screening.

5. Quality Assessment

The quality of the included studies was assessed. This involved evaluating the studies for risk of bias by looking at study design, conduct, and method of reporting.

6. Results Synthesis

The results of the included studies were synthesised. This involved importing the data into MS Excel for quantitative analysis and graphical representation of results. Papers were classified based on their contribution to the three categories of strategies, drivers, and challenges.

7. Interpretation of Findings and Conclusions

The findings were interpreted and conclusions were drawn based on the evidence gathered. This involved thematic analysis with an inductive approach, allowing for the identification and exploration of patterns and themes in the data without preconceived categories or concepts.

4. Findings and Discussion

In this section, the findings are grouped as follows, the challenges are linked to the relevant drivers and strategies that help overcome followed by a discussion on how they are connected.

Economic and Financial Challenges

Investment costs pose a significant challenge in collaborative logistics. However, the driver of local/regional development can help attract more investments into the sector. Coupled with the strategy of investing in infrastructure and technology, this can lead to more efficient operations, thus offsetting the initial investment costs (Nathanail et al., 2021).

Depreciation, particularly of infrastructure and equipment, is another economic challenge. Operational efficiency can act as a driver to slow down the rate of depreciation (McDonald et al., 2021). Regular maintenance and upgrade of equipment, as a strategy, can further extend the lifespan of assets and reduce the financial burden of depreciation (Gonzalez-Feliu, Pronello and Salanova Grau, 2018).

Profit sharing can be a contentious issue in collaborative logistics (Cleophas et al., 2019). Collaborating with local suppliers can drive a more equitable distribution of profits. Establishing clear

“and fair profit-sharing agreements as a strategy can help resolve disputes and ensure all parties benefit from the collaboration.

Organisational and Operational Challenges

Data sharing is a crucial operational challenge (Merkert, Bushell and Beck, 2020). The driver of sharing information and resources can facilitate safe and efficient data exchange. Implementing secure data sharing platforms as a strategy can further enhance this process, ensuring all parties have access to necessary data while maintaining confidentiality (Montoya-Torres, Muñoz-Villamizar and Vega-Mejía, 2016).

Trust between partners is essential for successful collaboration. Customer satisfaction can act as a driver to build and maintain trust among partners (Amiri and Farvaresh, 2023). Building long-term relationships based on trust and mutual benefit can be an effective strategy to overcome trust-related challenges.

Operational decisions made individually can lead to inefficiencies. Better use of resources can drive alignment in operational decisions among partners (Gonzalez-Feliu and Morana, 2010). Coordinating decision-making processes as a strategy can ensure all parties are on the same page, leading to smoother operations.

Legal and Regulatory Challenges

Excessive bureaucracy can hinder the progress of collaborative logistics. Reducing environmental impacts can act as a driver to advocate for streamlined regulations (Nathanail et al., 2021). This strategy can help reduce bureaucratic hurdles and promote environmentally friendly practices.

Legislation can pose challenges, especially when regulations differ between regions. Emissions reduction can act as a driver to ensure legal compliance. Complying with environmental regulations as a strategy can help address this challenge, ensuring all operations are within the bounds of the law (Peppel, Ringbeck and Spinler, 2022).

Confidentiality is a significant concern in collaborative logistics (Gonzalez-Feliu and Morana, 2010). Investment costs can drive the implementation of robust data security measures. This strategy can help protect confidential information, ensuring all parties feel secure in the collaboration.

Technological Challenges

Lack of data can hinder decision-making processes (Nathanail et al., 2021). Revealing new business opportunities can act as a driver to invest in data collection and analysis tools. This strategy can provide valuable insights for decision-making, helping to overcome this challenge.

Innovation in communication technologies can improve operational efficiency and communication among partners (McDonald et al., 2021). Increasing efficiency can act as a driver for adopting advanced communication technologies. This strategy can help improve communication and coordination among partners.

Managing information and communication flows can be challenging in complex networks (Gonzalez-Feliu and Morana, 2010). Increasing sales can drive the implementation of efficient information management systems. This strategy can help manage complex information and communication flows, leading to smoother operations.

Social and Cultural Challenges

“A shift in customer and company views is required for successful collaboration (Barros et al., 2021). Improving reputation can act as a driver to promote the benefits of collaboration. This strategy can help change perceptions and attitudes towards collaboration, leading to wider acceptance.

Social acceptance is crucial for the success of collaborative initiatives (Gonzalez-Feliu and Morana, 2010). Reducing environmental impacts can act as a driver to engage with the community and stakeholders (Rubini and Lucia, 2018). This strategy can help gain social acceptance for collaborative initiatives.

Loss of brand identity can be a concern for companies involved in collaboration (McLeod et al., 2020). Customer satisfaction can act as a driver to maintain a strong brand presence while collaborating. This strategy can help preserve individual brand identity, ensuring companies do not lose their unique appeal.

Environmental Challenges

Demand points in highly congested areas can pose significant logistical challenges (Demir, Syntetos and van Woensel, 2022). Less road congestion and noise-pollution can act as a driver to optimise delivery routes. This strategy can help reduce congestion and improve service in congested areas, leading to more efficient operations and less environmental impact (Huschebeck and Leonardi, 2020).

Strategic Challenges

Determining the shares in outcomes, costs, and resources can be a contentious issue in collaborative logistics (Amiri and Farvaresh, 2023). Sharing cost and benefits can act as a driver to establish clear agreements on resource sharing. This strategy can help resolve disputes over resource allocation, ensuring all parties are satisfied with the distribution of resources (Gonzalez-Feliu et al., 2013).

Poor strategic fit among partners can hinder the success of collaborative logistics (Pomponi et al., 2013). Increasing competitiveness by raising economies of scale can act as a driver to align strategic objectives among partners. This strategy can help ensure a good strategic fit among partners, leading to more effective collaboration.

Lack of a shared vision can lead to misalignment and conflict among partners (Konietzko, Bocken and Hultink, 2020). Increasing customer coverage can act as a driver to develop a shared vision and goals. This strategy can help align the vision and goals of different partners, ensuring all parties are working towards a common objective.

5. Theoretical Framework

As a result of the findings, the following theoretical framework could be used to understand and address the challenges in HC for LML, this is based on research that was undertaken outside the scope of this paper.

- 1. Transaction Cost Economics (TCE):** This theory can be used to understand the financial challenges in collaborative logistics, such as investment costs, depreciation, and profit sharing (Williamson, 1981). The strategies to mitigate these challenges could include investing in infrastructure and technology, regular maintenance and upgrade of equipment, and establishing clear and fair profit-sharing agreements.”
- 2. Resource-Based View (RBV):** This theory can be applied to address organisational and operational challenges such as lack of data, data sharing, and managing information and communication (Barney, 1991). Strategies under this theory could include implementing secure data sharing platforms, coordinating decision-making processes, investing in data collection and analysis tools, and implementing efficient information management systems.
- 3. Agency Theory:** This theory can help understand challenges related to trust between partners, confidentiality, poor strategic fit, and lack of shared vision (Jensen, 1976). Strategies to address these challenges could include building long-term relationships based on trust and mutual benefit, implementing robust data security measures, aligning strategic objectives among partners, and developing a shared vision and goals.
- 4. Institutional Theory:** This theory can be used to understand legal and regulatory challenges such as excessive bureaucracy, legislation, social acceptance, and loss of brand identity (Scot, 1975). Strategies to mitigate these challenges could include advocating for streamlined regulations, complying with environmental regulations, engaging with the community and stakeholders, and maintaining a strong brand presence while collaborating.
- 5. Stakeholder Theory:** This theory (Freeman, 1984) can be applied to address technological challenges such as innovation in communication technologies, large-scale demand, time- differentiated delivery services, and demand points in highly congested areas. Strategies under this theory could include adopting advanced communication technologies, investing in infrastructure and technology, promoting the benefits of collaboration, and optimising delivery routes.
- 6. Sustainability Theory:** This theory can be used to understand environmental challenges such as reducing environmental impacts, emissions reduction, greenhouse gas emission reduction, and less road congestion and noise pollution (Dyllick, 2002). Strategies to address these challenges could include advocating for streamlined regulations, complying with environmental regulations, engaging with the community and stakeholders, and optimising delivery routes.

This theoretical framework provides an understanding of the challenges in collaborative logistics and the drivers and strategies that can be employed to address these challenges. It allows for a holistic view of the situation, taking into account various aspects such as economic, organisational, legal, technological, social, and environmental factors. Ultimately, this framework could lead to improved environmental outcomes and increased competitiveness for organisations involved in urban LML (Van Duin et al., 2013; Allen et al., 2012).

6. Conclusion

In conclusion, this study has examined the potential of HC in urban LML, with the aim of enhancing sustainability and competitiveness. Through a comprehensive literature review, key drivers, strategies, and challenges of HC in LML have been identified.

HC has been recognised as a valuable solution to the challenges faced by LML, particularly with the rapid growth of e-commerce and urbanisation. Collaborating with companies at the same supply chain level can lead to operational efficiency, cost reduction, and environmental sustainability.

Addressing economic, organisational, legal, technological, social, and environmental challenges is crucial for successful implementation of HC in LML. Specific strategies and approaches are required to overcome these challenges and ensure effective collaboration.”

“However, it is important to acknowledge the current literature’s limitations, particularly the lack of a comprehensive framework. Future research should include qualitative methods such as semi- structured interviews with logistics professionals to gain deeper insights and develop a comprehensive framework for sustainable HC in urban LML.

Overall, this study provides a basis for further research and practical applications in the field of HC in LML. By promoting collaboration and leveraging the identified drivers and strategies, organisations can overcome challenges, achieve sustainability goals, and maintain a competitive advantage in the dynamic urban last-mile logistics landscape.

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OPTIMISING THE LOGISTICS OF URBAN HEALTHCARE THROUGH A SHARED-FLEET COLLABORATION

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Introduction

Shared-fleet logistics, a form of horizontal collaboration where organisations consolidate loads and share vehicle capacity to improve vehicle utilisation, is often proposed as a solution for logistics inefficiencies. This approach has the potential to generate cost savings for all parties involved while reducing the negative impacts of road logistics, such as vehicle kilometres (vkm), vehicular emissions, and traffic congestion (Ferrell et al., 2020; Amiri and Farvaresh, 2022).

Shared-fleet collaborations have the potential to provide benefits in healthcare logistics, a possibility explored in this study. The NHS operates a Sample Collection Service (SCS) to transport pathology samples from General Practitioner (GP) surgeries to centralised pathology laboratories for analysis. This transportation service is typically outsourced to external commercial courier companies. Southampton City Council (SCC) operates a courier service using five Light Goods Vehicles (LGVs), primarily for internal mail and for school meal deliveries. This study aims to assess the feasibility of using SCC courier vehicles to undertake the SCS for an NHS Trust in Southampton, delivering pathology samples to Southampton General Hospital (SGH). The goal was to leverage the fleet of SCC, as a provider, to enhance the utilisation of their own-account vehicles and eliminate the need for external commercial carriers. Secondly, the study aimed to quantify the potential benefits of this shared-fleet logistics collaboration, specifically focusing on electric vehicles, by conducting a case study using real-world data. The benefits considered included cost reduction, decreased vehicle kilometres travelled, and reduced CO₂ emissions.

Literature Review

Existing research primarily focuses on the strategies and benefits of shared-fleet operations, where commercial carriers form coalitions to exchange transportation requests and meet the demand for transporting goods on a network-wide scale. Recent literature reviews in this field reveal that methodologies are frequently based on computational approaches using theoretical instances, with comparatively few studies utilising data from real-world activities (Gansterer and Hartl, 2020; Aloui et al., 2021; Mrabti, Hamani and Delahoche, 2022).

While environmental benefits are often considered, existing research predominantly emphasises economic benefits and how to distribute these equitably among cooperating partners (Wang et al., 2018; Basso et al., 2023; Amiri and Farvaresh, 2022; Serrano-Hernandez et al., 2021). Research by Chabot et al. (2018) involving general freight shipments from Quebec City, Canada, to the USA showed that shared-fleet collaborations could lead to cost and emission reductions of up to 52% and 80%, respectively. Aktas et al. (2020) assessed vehicle capacity sharing in last-mile deliveries for London's online grocery sector, revealing potential reductions of 17% in vkm and 22% in the number of vehicle routes. Jerbi et al. (2022) investigated the impact of supply chain transportation pooling strategies. A theoretical case study involving two manufacturing companies and three customers revealed that pooling strategies can lead to a CO₂ emissions reduction of up to 13% compared to non-pooled strategies.

Other studies of shared fleet collaboration that incorporate real-world operational data, include those of Vargas et al., (2020), and Grote et al., (2023), both demonstrating potential reductions in vehicle kms and associated emissions.

Materials and Methods

Business-As-Usual (BAU) Scenario

The study relied on two primary datasets that detailed vehicle round structures: one for the SCC in May 2023 and the other for the SCS in September 2018. A secondary dataset containing the total number of pathology samples produced in March 2021 was also used. The SCC dataset described the daily movements of five local authority courier vehicles (Figure 1). The SCS dataset described the daily movements of 10 third-party courier service vehicles, collecting pathology samples from 78 GP surgeries (Figure 1) in and around Southampton.

Each weekday, the SCC courier service completes five scheduled rounds using two electric LGVs (5.3m³ capacity, 330 km range and 1000kg payload) and three hybrid vehicles (6.0m³ capacity, 500km range, 1150kg payload). These courier rounds have spare capacity, including some periods when vans are specifically scheduled to be empty and idle to be ready for ad hoc work demands.

From the SCS data, the number of samples collected from each GP surgery each day ranged from only a few to up to 200 samples, depending on the size of the surgery and the number of registered patients. On average, there were 40 samples produced per day per surgery. These samples are carried in insulated medical carriers known as Versapaks, each 460x305x255mm in size, with an empty weight of 2.4kg and able to carry around 125 samples. Samples are collected from each surgery twice daily (e.g., morning and afternoon).

The SCS data gave the movements of 10 courier vehicles (diesel vans) conducting 10 collection rounds daily in the BAU scenario and visiting up to 18 surgeries before delivering to SGH. These vehicles also delivered empty Versapaks to GP surgeries at the same time as collecting those containing samples.

Vehicle kilometres (vkm) and active duration (the time the vehicle and driver were functioning) were extracted from the two primary data sources. Distances among the postal code locations of each stop on the vehicle routes in the datasets were evaluated using Google Maps and confirmed with GraphHopper (a web-based application resembling Google Maps). Active durations were computed by finding the difference between the recorded times of vehicles leaving and arriving back at the depot in the datasets.

CO₂ emissions values were acquired from WebTAG tables (DfT, 2023), and from the 'Manager's Guide to Distribution Costs' (FTA, 2022). The values indicated 0.28kg/km for diesel vehicles and 0.07kg/km for electric/hybrid vehicles.

Driver and vehicle operating costs were taken from the 'Manager's Guide to Distribution Costs' (FTA, 2022). It was assumed that courier driver wages would be similar to those given for drivers of light rigid vehicles (≤ 7.5 tonnes GVW) (£11.93/hour), and all vehicles were assumed to have a single operator (i.e., the driver). Vehicle operating costs of (£0.11/km) and (£0.13/km) were assumed for electric/hybrid and diesel LGVs, respectively (≤ 3.5 tonnes GVW averaging 39,600 km/year) (Transport & Environment, 2022), where these include the net vehicle cost, energy consumption-related costs (diesel or electricity), maintenance, insurance, and taxes. For electric vehicles, the cost of installing an EV charging station was also included in their analysis (Transport & Environment, 2022).

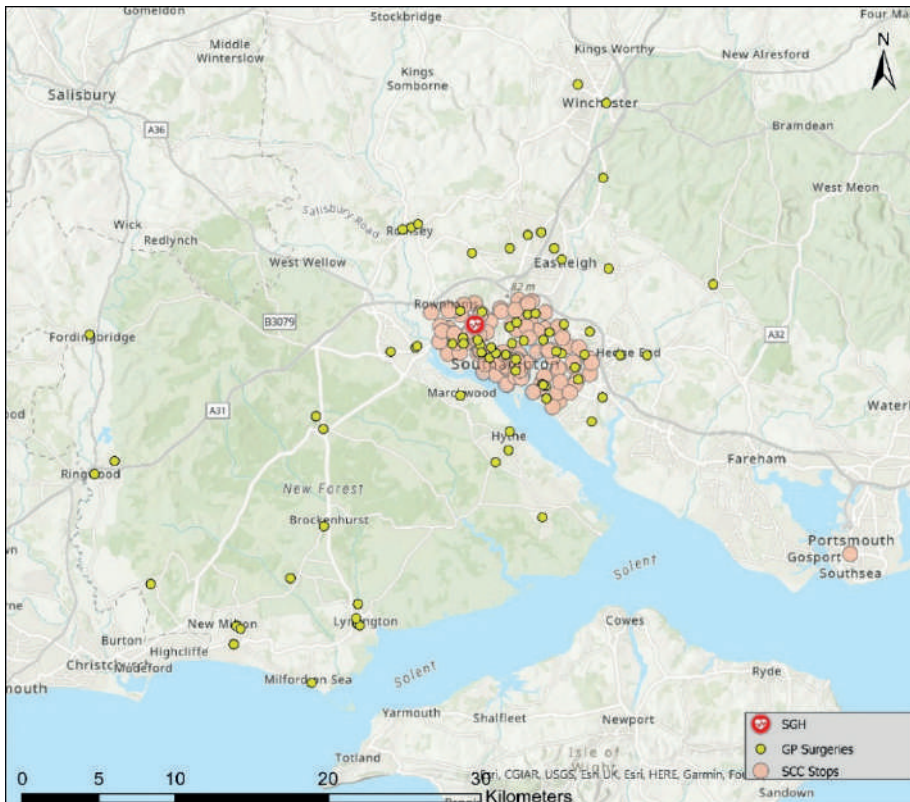


Figure 1: Map showing the 78 GP surgeries, SGH and SCC courier vehicles' stops.

Intervention Scenario

In the proposed shared-fleet operation model, it was assumed that all samples were collected by SCC vehicles instead of the courier company currently contracted. This alternative scenario diverges from the BAU scenario by incorporating four additional electric vehicles to accommodate the extra work involved. Daily task lists encompassing SCC and SCS tasks and all associated time windows were generated using historical datasets. These were given as input data for the commercially available route optimisation software, PTV Route Optimiser, to identify the most efficient vehicle routes to accomplish all required collections and deliveries, while complying with regulations that stipulate that drivers must take a minimum break of 45 minutes after driving 4.5 hours. The utilisation of commercially available software was considered adequate for discovering efficient solutions for this feasibility assessment of the SCC/SCS shared-fleet operations concept. The exploration and development of innovative algorithmic optimisation techniques is viewed as a potential avenue for future research.

SCC time windows included those relating to school meals (pickup, delivery and subsequent collection of empty plates etc.), where five vehicles were allocated and made available from 10:30am to 1pm. For the SCS, time windows for twice-daily collections from GP surgeries were set as 09:30-13:00 and 14:30-16:30, respectively, while delivery time windows for the collected samples to SGH were set as 13:00-14:30 and 16:30-17:00.

SCC vehicle capacities were considered in optimising the shared-fleet operation, ensuring that a maximum of 20 Versapaks were carried simultaneously by each vehicle. Vehicle dwell time per stop was set at an assumed value of three minutes for each SCC task, four minutes for each GP surgery, and eight minutes for deliveries to SGH.

The BAU duty periods for SCC drivers, as outlined in the SCC courier vehicle rounds dataset, typically had a maximum duration of 9.5 hours (with an average of approximately 8.7 hours), which was also assumed as the maximum for the intervention scenario (with a maximum of 9.5 hours and an average of about 8.65 hours). Break requirements for SCC drivers were taken into consideration (60 minutes for lunch and 10-15 minutes for an afternoon break in BAU). In the intervention scenario, drivers were assumed to have breaks in line with SCC requirements (1 hour for lunch and 50 minutes while the vehicle is being charged).

Regarding the charging of electric vehicle batteries, a minimum of 50 minutes was allocated for charging each vehicle along the route in the intervention scenario. Since only one fast charging point is available at the SCC courier depot (with plans to increase the number), charging periods were assigned separately to avoid conflicts or delays. Moreover, SCC required a daily spare amount of time across the fleet of 120 minutes to handle unforeseen issues or inquiries. To accommodate this requirement, one of the nine routes was optimised to ensure a 120-minute time window was available. This was achieved by limiting the working hours of a particular route to allow for a 2-hour period of free time before the end of the daily shift.

Additionally, it should be noted that SCC drivers use their homes as depots, starting and finishing their daily routes from their home addresses. This constraint was taken into account in the intervention scenario for the five existing SCC couriers. An SCC depot was taken as the start and end point for the four new vehicles although, in practice, those vehicles would also likely be taken home by the new drivers.

Vkm and duty time data were derived from route optimisation software outputs, applying the same cost factor values as those used in the BAU analysis. The software did not include an integrated emissions model, so the fixed emission factor from the BAU analysis (0.07 kg/km for electric/hybrid vehicles (DfT, 2023)) was applied to vkm outputs to determine CO₂ emissions. Regarding the distance range of the vehicles, the study implemented a constraint where the total distance covered in each route did not exceed the electric vehicles' range of 330km. Metin girmek için buraya tıklayın veya dokununuz.

Results and Discussion

In the intervention scenario, four additional vehicles were required to accommodate the workload of both SCS and SCC effectively. Consequently, a total of nine vehicles were allocated, resulting in the creation of nine daily routes. Extensive discussions were held with the staff of SCC to ensure the feasibility of implementing these routes, considering various constraints such as charging times, breaks, working hours, and availability of vehicles during the collection and delivery of school dinners.

To assess the potential benefits of implementing a shared-fleet operation, a comparative analysis was conducted between the results of the BAU and intervention scenarios (Table 1). The case study's findings indicated a considerable reduction in CO₂ emissions, amounting to 69% (237 kg/day), mainly achieved through the use of electric/hybrid vehicles in the intervention scenario. A modest reduction of 3% (52 km/day) in vehicle kilometres was also observed. Moreover, substantial reductions were observed in the number of vehicle routes, duty time, and costs, demonstrating reductions of 40% (6 vehicles/day), 14% (11 hours 39 minutes per day), and 14% (GBP (£) 168/day), respectively. Furthermore, it is worth noting that from the analysis, it is possible to extrapolate annual estimates by multiplying the daily average values by 253, representing the total number of working days per year. Based on this approach, the findings indicate potential annual savings as follows: a reduction of 1,518 vehicle rounds, amounting to 13,156km travelled, 2,947 hours and 27 minutes of duty time, 59.961 tonnes of CO₂ emissions, and GBP (£) 42,504 in costs. The longest route distance was 225km among 9 new routes, which falls within the electric vehicles' range limit of 330km. It can be inferred that all routes are feasible in terms of the vehicles' distance capacity.

The analysis conducted in this study has demonstrated the feasibility of implementing a shared-fleet operation involving two public sector participants using an own-account electric vehicle fleet. Specifically, during March 2021, the collaboration between SCC and SCS allowed for the fulfilment of all transportation requirements for pathology samples as well as the daily tasks of SCC. The observed benefits (including reductions in the number of vehicles, cost, vkm, duty time, and CO₂ emissions by 40%, 14%, 3%, 14%, and 69%, respectively, Table 1) emphasise the importance of actively seeking shared-fleet solutions to enhance vehicle utilisation. Public sector organisations, such as SCC, should consider implementing policies to harness these benefits. Such policies can potentially reduce public sector expenditure and alleviate the challenges associated with road-based logistics, such as air pollution, climate change, and traffic congestion. While this study focused on a large public sector organisation in the UK (i.e., the NHS), its implications are likely to extend to similar contexts worldwide, wherein various public sector entities (e.g., municipal authorities, healthcare providers, government departments, education providers, and infrastructure providers) operate their own vehicle fleets and could benefit from load consolidation through shared vehicle capacity.

Table 1: Daily statistics for SSC and SCS in both BAU and intervention scenarios.

	Scenario & Service				
	BAU Daily Average ¹			Int. Daily Average ²	
	SCC	SCS	Total	Shared-Fleet	Net Effect ³ (% reduction)
No. of Vehicle Routes	5	10	15	9	6 (40%)
Vkm (km)	420	1182	1602	1550	52 (3%)
Duty Time (h:m)	43:30	42:10	85:40	74:01	11:39 (14%)
CO₂ (kg)	29	317	346	109	237 (69%)
Cost (GBP)	£565	£656	£1,221	£1,053	£168 (14%)

¹ BAU is Business-As-Usual. ² Int. is Intervention. ³ Net effect = BAU – Int.

Regarding costs, it is important to note that the cost savings anticipated in the intervention scenario could potentially surpass the 14% reduction (corresponding to a daily saving of GBP (£) 168) indicated in Table 1. This estimation is based on the cost incurred by the courier company in providing the collection service in the BAU scenario. As a profit-oriented enterprise, the courier company would likely include a profit margin when tendering for the SCS contract. Consequently, the cost savings for the NHS due to avoiding the need to engage an external courier company could be even greater than initially projected.

Practical Issues and Research Limitations

Despite the potential benefits highlighted by implementing a shared-fleet operation, it is essential to acknowledge the presence of practical constraints that may hinder its real-world deployment. These constraints may stem from various factors, including preferences for collection/delivery times, existing supplier contracts and pricing, specific delivery time requirements for SCC operations, and the reliability of travel times on the designated routes examined in this study. Consequently, these constraints can potentially increase vkm, emissions, and the number of vehicles used, posing challenges in fully realising the expected environmental and operational advantages envisioned by the intervention scenario.

In practical terms, several barriers and constraints could impact the successful deployment of a shared-fleet operation in the real world (Vargas et al., 2020; Karam e al., 2021; Grote et al., 2023). These factors include:

1. Meeting the preferred collection and delivery times.
2. Unforeseen delays in vehicle operations.
3. Reliability of routes, travel times, and loading/unloading times.
4. Adhering to existing service level agreements.
5. Ensuring the secure storage of samples within the vehicles.
6. Quality control measures necessary to monitor and mitigate dangerous in-vehicle conditions like temperature or vibration.
7. Mitigating the risk of sample loss or damage.
8. Convincing all parties involved, including GP surgeries, SCC vehicle drivers, SCC and NHS management staff, and pathology laboratory personnel, about the benefits of participation.
9. Availability of spare capacity in SCC vehicles.
10. Allocating responsibility for route scheduling.
11. Developing a fair business model that allocates costs and benefits among the collaborating parties, including agreements on cost allocation and management processes.
12. Establishing a new contract between SCC and the NHS for transporting pathology samples.

Regarding research limitations, it is important to acknowledge that the data used in this study has certain temporal discrepancies, as the SCS data was obtained in March 2021, while the SCC data was collected in May 2023. The historic pathology sample generation dataset utilised in the analysis indicates a relatively consistent demand pattern over time, with no discernible seasonal variations and a stable monthly sample volume from the participating surgeries. Consequently, in a real-world implementation, it is unlikely that the SCC vehicle fleet would encounter unexpected sample collection requests beyond those accounted for in the analysis.

Furthermore, it should be noted that the benefits identified in this study are specific to the particular case study examined. To comprehensively assess the feasibility and effectiveness of shared-fleet operations between public organisations, conducting real-world trials and expanding collaborations to include additional parties and shared vehicles is imperative. A more comprehensive understanding of the applicability and reliability of shared-fleet operations in the public sector can be achieved by conducting such trials and engaging in new case studies. New case studies and trials would enable a broader assessment of the potential benefits and limitations of collaborative initiatives, thereby informing future decision-making processes and facilitating the adoption of efficient and sustainable transportation practices within the public sector.

Conclusions

The research findings demonstrate the feasibility and potential benefits of collaborative shared-fleet operations, emphasising their significant impact on environmental sustainability and transport-related challenges. The results of the case study showed that shared-fleet operations could reduce vehicle numbers and vkm. The substantial 69% reduction in CO₂ emissions achieved through the adoption of electric vans contributes to climate change mitigation and improved air quality in the operating area. It can be suggested that Local Authorities play a crucial role in promoting the use of electric vehicles and integrating them into their own operations.

In summary, this study made several significant contributions. Firstly, it provided evidence supporting the feasibility and potential benefits of collaborative shared-fleet operations involving public sector own-account vehicle fleets and addressing healthcare logistics demands for specialised payloads, a relatively unexplored area in previous literature. Secondly, the study quantified the potential benefits of such collaborations, highlighting their value in practical terms. Thirdly, it identified the potential for wider implementation of shared-fleet operations by other public sector organisations facing similar challenges worldwide. Lastly, this research helped address the existing gap in the literature, specifically the lack of studies based on real-world activity data related to shared-fleet collaborations.

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E-WASTE AND THE CIRCULAR ECONOMY: EXPLORING CONSUMER PERSPECTIVES IN THE UNITED ARAB EMIRATES

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Introduction

The rapid adoption and obsolescence of consumer electronics have led to a concerning surge in electronic waste, or e-waste. Globally, up to 50 million tonnes of electronic and electrical waste (e-waste) is generated annually (UNEP, 2019). However, a mere 20% of this waste is recycled. This is alarming, given that the global production of e-waste is forecasted to reach 75 million tonnes per year by 2030 (Islam et al., 2021). The discarded e-waste often ends up in landfills, posing significant environmental and health risks due to the presence of toxic and hazardous substances like mercury, arsenic, lead, and cadmium (Kochan et al., 2016; Siddiqua et al., 2022). These substances can lead to cancer, allergies, and other severe health issues (Kochan et al., 2016). Besides the adverse effects on health and the environment, inadequate handling of e-waste leads to substantial losses of precious and limited raw materials, including gold, platinum, cobalt, and rare earth elements. The yearly value of raw materials discarded as e-waste is approximately USD 57 billion (Siddiqua et al., 2022). E-waste may hold up to 7% of the world's gold, with a tonne of e-waste containing 100 times more gold than a tonne of gold ore (UNEP, 2019). Governments and organizations worldwide are therefore looking at innovative approaches to manage e-waste.

The circular economy concept supports effective e-waste management by fostering a closed-loop system in which resources are consistently utilized, repurposed, and recycled, thereby reducing waste, and optimizing resource efficiency (Mohammadi et al., 2021). All stakeholders have a part to play in the circular economy, but prioritizing a consumer-centric approach is crucial, as improper actions often lead to e-waste ending up in landfills (Islam et al., 2021). This entails motivating consumers to engage in appropriate e-waste disposal, recycling, and refurbishment initiatives and making informed decisions when purchasing electronic products. Despite consumers' crucial role in managing e-waste, few studies have examined the issue from their perspective. This gap is even more pronounced in high-income Middle Eastern countries.

These identified gaps in existing research served as the impetus for this study, which employs a consumer-focused strategy to address e-waste challenges. The UAE was chosen as the research setting of this investigation due to its status as a high-income nation in the region, generating an annual e-waste output of 15 kg per capita, more than twice the global average (Siddiqua et al., 2022). The study's specific objectives include:

- a) Examine consumers' environmental awareness on the negative consequences of e-waste
- b) Examine consumers' perceived convenience related to recycling e-waste
- c) Examine consumers' intention to recycle e-waste
- d) Examine consumers' actual recycling behaviour.
- e) Examine the relationship between consumers' environmental awareness, perceived convenience, intention to recycle e-waste and actual recycling behaviour

The study's findings offer insights into consumers' awareness of e-waste issues, their e-waste recycling intentions, and their actual behaviour. Practitioners and policymakers in the UAE and elsewhere could use the findings to develop strategies and policy interventions to improve e-waste management, such as raising awareness about e-waste and enhancing the convenience of e-waste recycling facilities.

Literature Review

In line with the research objectives, relevant studies on e-waste and circular economy practices in the electronics sector are reviewed to develop a conceptual model and frame hypotheses. They are discussed in the following sections:

Consumers' environmental awareness of e-waste consequences and recycling intention

Awareness of environmental consequences is defined as an individual's recognition of the environmental impact resulting from their actions. Most previous studies have shown that awareness of environmental consequences positively predicts the recycling intentions of consumers (Domina and Koch, 2002; Wan et al., 2012). Kochan et al. (2016) study on university students found a significant and positive (though relatively weak) relationship between environmental awareness of e-waste consequences and e-waste recycling intention. However, a few studies, such as Kumar (2019), found that awareness of consequences did not exhibit any correlation with recycling intention. Despite these contradictions in recycling literature, it could still be argued that as society's awareness of environmental consequences increases, so does their intention to participate in e-waste recycling activities. Therefore, the following hypothesis is proposed:

H1: Consumers' environmental awareness of e-waste consequences will positively impact their e-waste recycling intention.

Perceived convenience and e-waste recycling intention

Perceived convenience of e-waste recycling refers to an individual's assessment of the time and ease involved in managing e-waste (Tonglet et al., 2004). Recycling intention refers to an individual's probability of recycling e-waste in the future (Konchan et al., 2016). When consumers view recycling as a convenient activity, they are more inclined to participate in recycling (Sidique et al., 2010). Past research indicates that conveniences such as the availability and accessibility of recycling centres play a significant role in fostering recycling intentions (Domina and Koch, 2002; Saphores et al., 2006; Sidique et al., 2010). Darby and Obara (2005) study found that the number of participating consumers tends to decrease when the distance to recycling centres increases. Kelly et al. (2006) examined attitudes toward recycling within a university and discovered that placing more bins in accessible strategic locations increased the student's engagement in recycling. Likewise, Saphores et al. (2006) explored the willingness to recycle e-waste at drop-off centres and determined that convenience factors, such as proximity to recycling facilities, contributed to increased intention towards e-waste recycling. Kochan et al. (2016) study found a weak but significant positive relationship between perceived convenience and e-waste recycling intention. Therefore, we propose the following hypotheses:

H2: Consumers' perceived convenience of e-waste recycling will positively impact their e-waste recycling intention.

E-waste recycling intention and actual recycling behaviour

According to the Theory of Reasoned Action (TRA), the intention towards a particular behaviour is the most important determinant of whether they will actually engage in that behaviour. A comprehensive review conducted by Islam et al. (2021) found evidence of e-waste recycling intentions leading to actual recycling behaviour. Kochan et al. (2016) study found a significant and moderate positive relationship between e-waste recycling intention and recycling behaviour. Hence, we propose the following hypotheses:

H3: Consumer's e-waste recycling intention will positively impact their actual e-waste recycling behaviour.

The four constructs and their hypothesised relationships are shown in Figure 1.

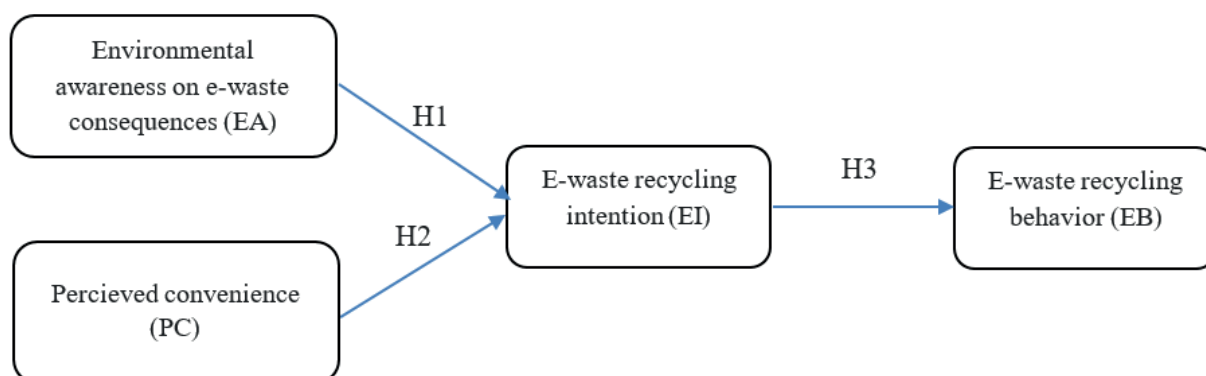


Figure 1: Proposed Conceptual Model

Methodology

A survey methodology was adopted in this study. The conceptual model (see Figure 1) and the measurement items were developed from the literature (Konchan et al., 2016; Wang et al., 2016). A 5-point Likert scale was used to capture the respondent's opinions. In addition, several demographic questions and open-ended questions were included to obtain more detailed information. The online survey using a convenient sampling method was conducted in July-August 2022 using the Qualtrics survey platform. After removing incomplete responses, a total of 106 usable responses were obtained. The demographic detail of the participant is given in Table 1. For data analysis, SPSS and AMOS were used to analyse the data and test the hypotheses.

Variable	Responses	Percentage
Gender		
Male	44	41.5%
Female	62	58.5%
Total	106	100%
Age		
18-24	20	18.9%
25-29	28	26.4%
30-39	35	33.0%
40-49	14	13.2%
Above 50	9	8.5%
Total	106	100%
Education		
High School/Diploma	21	19.8%
Bachelor's Degree	49	46.2%
Master's degree or above	31	29.3%
Others	5	4.7%
Total	106	100%
Size of Household (Persons)		
1-2	46	43.4
2-5	43	40.6
6-10	12	11.3%
Above 10	5	4.7%
Total	106	100%

Table 1: Demographic details of participants

Findings and Discussions

The study findings are organized in line with the research objectives. The descriptive statistics on the four main constructs of this study are provided in Table 2.

Construct	Mean ($\bar{x}$)	Standard Deviation (SD)
Environmental awareness (EA)	3.30	0.83
Perceived convenience (PC)	2.89	1.10
E-waste recycling intention (EI)	4.28	0.78
E-waste recycling behaviour (EB)	2.75	1.00

Table 2: Descriptive Statistics

Environmental Awareness

As shown in Table 2, consumers in the UAE exhibit only moderate environmental awareness ($\bar{x} = 3.30$) despite the fact that more than two-thirds of the participants are educated with a Bachelors or Masters degree and above. The need to increase awareness and education is consistently mentioned in the qualitative comments. Select respondents' comments are given in Table 3:

S. No	Description
Quote 1	Increase awareness of the effects of e-waste on the environment and humans
Quote 2	Nobody or few people know how to recycle electronic devices
Quote 3	There is a lack of rules and guidelines from the government about how to recycle e-waste
Quote 4	Need to advertise or educate people on how to recycle electronics properly
Quote 5	Spread awareness and educate consumers on how and why they should dispose of electronics properly
Quote 6	Make social media announcements on e-waste recycling because many people do not know that we can recycle the electronic devices

Table 3: Select respondents' quotes on environmental awareness

These findings align with those of Siddiqua et al. (2022), who identified an awareness gap regarding e-waste disposal among UAE consumers. Their study revealed that merely two-thirds of the respondents recognized the presence of toxic components in e-waste, while less than half were aware that e-waste could contribute to environmental pollution (air, water, and soil). Hence, it is essential to intensify efforts aimed at boosting consumers' environmental consciousness concerning the ramifications of e-waste and the advantages of recycling it (Islam et al., 2021). Islam and Huda (2020) emphasize the critical role local governments must play in fostering public cognizance of the effects of e-waste. Furthermore, Liu et al. (2019) strongly advocate for the promotion of environmental education as a means to elevate consumer awareness pertaining to e-waste recycling.

Perceived Convenience

As seen in Table 2, the perceived convenience of UAE consumers in e-waste recycling is relatively low ($\bar{x} = 2.89$). One of the primary respondent concerns was the lack of drop-off or lack of collection points. Some of the respondents' comments are given in Table 4:

S. No	Description
Quote 1	Build a convenient way for people to dispose of them without taking a huge effort
Quote 2	Provide a more accessible area to drop off damaged devices
Quote 3	Recycling locations should be in every area, like the building I live right now doesn't have a recycling bin. It should be implemented in all areas
Quote 4	There should be reliable service centres and repair shops for all electronic devices
Quote 5	There are not enough designated locations for dropping off electronic waste
Quote 6	E-waste drop-off points are very far from my home

Table 4: Select respondents' quotes on perceived convenience

Previous studies have also reported lower perceived convenience due to a lack of respondents' access to e-waste collection centres or recovery/recycling facilities around their residential areas (Dwivedy and Mittal, 2013). In sum, perceived convenience largely depends on the availability and accessibility of recycling facilities.

E-waste Recycling Intention

Table 2 shows that e-waste recycling intention is high among UAE consumers ($\bar{x} = 4.28$). The popular ways in which they intend to recycle waste include; exchanging old products for new ones with retailers (9%); selling items in the second-hand market (15%); donating working devices to friends and family (24%), and donating to charitable organizations (6%). These findings align with prevalent e-waste recycling intentions found in the literature, such as depositing e-waste at nearby drop-off stations and returning it to retailers or manufacturers (Konchan et al., 2016).

E-waste Recycling Behaviour

As shown in Table 2, E-waste recycling behaviour is low among UAE consumers ($\bar{x} = 2.75$). This indicates that even if there is an intention, it is not translating into actual behaviour. However, this does not imply that consumers blindly discard e-waste. In fact, most surveyed UAE consumers are keeping the e-waste stockpile at their home, awaiting an opportunity to recycle. Only a few respondents have highlighted that they dispose of e-waste along with other garbage. Therefore, the relatively low recycling behaviour despite the high intention to recycle (intention-behaviour gap) could be attributed to the lack of recycling opportunities. For instance, consumers mentioned the main reason to buy new devices is that their old device is damaged and that there is a lack of service or repair centres. This highlights the need for more repair centres to reduce e-waste. The other reason for the intention-behaviour gap is that consumers need more financial incentives to participate in recycling behaviour. Also, concerns related to data security are contributing to the consumers' reluctance to participate in e-waste recycling behaviour (despite having positive intentions). They worry about personal data being retrieved or stolen from the recycled devices. Some of the respondents concerns are given in Table 5.

S. No	Description
Quote 1	If companies offer discounts on new products in exchange for old ones, this encourages people to return their devices to manufacturers
Quote 2	Tech companies should pay more for trade-in options when a customer buy wants to buy a new device
Quote 3	More rewards from retailers when exchanging old devices for new ones
Quote 4	I am not convinced how recycling companies will ensure my data is not misused

Table 5: Select respondents' quotes on impediments to recycling behaviour

Hypothesis				Standardized Coefficients (β)	t-statistic	p-value	Result
H1	EA	→	EI	0.382	3.782	0.000***	Supported
H2	PC	→	EI	0.402	3.808	0.000***	Supported
H3	EI	→	EB	0.671	3.315	0.001**	Supported

Table 6: Hypotheses Test Results

Relationship between environmental awareness and e-waste recycling intention (H1)

The results indicate a positive impact of environmental awareness regarding e-waste consequences on the intent to recycle e-waste, thereby supporting hypothesis H1. This moderately strong and positive significant relationship is represented by $\beta = 0.382$ and $p < 0.001$. The results also corroborate the prevalent view in existing literature, suggesting that an increased understanding of environmental consequences leads to a higher likelihood of consumers intending to recycle (Domina and Koch, 2002; Wan et al., 2012; Kochan et al., 2016) and rejects the conflicting notion that awareness did not influence

recycling intention (Kumar, 2019). However, at present, the awareness level is moderate. According to respondents, a collective effort by all stakeholders, such as government, community groups, manufacturers, and retailers, is required to increase awareness of the adverse environmental impact of e-waste.

Relationship between perceived convenience and e-waste recycling intention (H2)

The results also indicate a positive impact of perceived convenience on the intent to recycle e-waste, thereby supporting hypothesis H2. The relationship is positive and significant but moderate at $\beta = 0.402$ and $p < 0.001$. The results can be summarized in the words of one of the respondents:

“If there were more drop-off spots, I would gladly take the drive to drop my e-waste”

The results support the previous research that highlights the importance of convenience, such as the availability and accessibility of recycling centres, in promoting recycling intentions (Domina and Koch, 2002; Sidique et al., 2010). This includes proximity to recycling facilities and recycling programs (Darby and Obara, 2005; Saphores et al., 2006).

Relationship between e-waste recycling intention and actual behaviour (H3)

The intention to recycle e-waste was found to positively influence the e-waste recycling behaviour of UAE consumers, thereby supporting hypothesis H3. In fact, this positive relationship was found to be strong and significant at $\beta = 0.671$ and $p < 0.001$. The results align with the literature findings and the theory of reasoned action that intention leads to behaviour. However, the relationship is stronger than in previous studies (Konchan et al., 2016).

Conclusions

This study's implications are numerous and varied. This study is timely given the dramatic rise in e-waste presents a worldwide challenge with considerable environmental, social, and economic consequences. The worldwide e-waste is expected to reach 120 million tonnes annually by 2050 (UNEP, 2019). Environmentally, e-waste is a leading cause of water, air, and soil contamination. Regrettably, less than 20% of e-waste is properly recycled, while the remaining 80% is disposed of in landfills. This disposal releases dangerous, cancer-causing substances like mercury, lead, and cadmium, posing significant health risks to society. Economically, e-waste leads to the considerable loss of scarce and valuable raw materials such as gold, platinum, and other rare earth elements (UNEP, 2019).

In terms of research implications, this study adds to the growing body of literature on e-waste recycling from a consumer-focused viewpoint. This customer-centric approach is critical given that they are one of the key stakeholders in tackling e-waste. This study also addresses the research gap concerning e-waste recycling in high-income Middle Eastern countries, particularly the UAE. The study also contributes to the growing literature around the circular economy approach that encourages waste reuse, repair, and recycling, reducing waste and preserving valuable resources.

Theoretically, this study presents a conceptual model based on the Theory of Reasoned Action (TRA) to investigate the connections between an individual's awareness, convenience, intentions, and behaviours related to e-waste recycling. The study validates the proposed hypotheses, illustrating that increased environmental awareness of e-waste consequences and the perceived ease of recycling e-waste contribute to a robust intention to recycle e-waste. This strong intention, in turn, leads to active participation in e-waste recycling.

From a policy standpoint, this research is particularly relevant to the UAE, as the country has declared 2023 as the “Year of Sustainability” and is committed to environmental protection and climate action. The UAE will host the 28th Conference of the Parties to the UN Framework Convention on Climate Change (COP28), and this study offers valuable recommendations for the UAE to encourage e-waste recycling and reduce its environmental impact. For example, the government should lead the effort to raise public awareness of the environmental and human health consequences of improper e-waste disposal. The study indicates that increasing public awareness of environmental protection can lead to environmentally friendly behaviour. The government could collaborate with schools and universities to incorporate environmental pollution topics, including e-waste, into their curricula. This is echoed in the views of one of the respondents, who highlighted the importance of integrating e-waste management into academic materials. The government should also consider partnering with private

companies to establish recycling infrastructure, such as collection, sorting, and recycling facilities, as the current lack of infrastructure is a significant issue in the UAE. UAE residents are calling for easily accessible recycling bins or drop-off locations, like metro stations or residential buildings.

For practitioners, the findings reveal significant economic and business opportunities for companies to establish recycling facilities in the UAE. Retailers should support e-waste recycling initiatives by offering appealing incentives, such as discounts on new products in exchange for old electronic devices, encouraging people to sell or exchange their e-waste for useful materials. Retailers and manufacturers should communicate with consumers on ways to dispose of their obsolete products. Several respondents highlighted the importance of social media as an effective platform for creating awareness. The government could provide incentives or assert pressure on manufacturers and retailers to implement e-waste recycling programs, such as trade-in options. Furthermore, consumers emphasized the need for cost-effective service centres and repair shops for electronic devices.

This study, however, has certain limitations. Firstly, its focus on the UAE may restrict its generalizability. Additionally, the sample size is relatively small. Future research could explore similar issues in other high-income countries in the region, such as Saudi Arabia. Moreover, this study only considers two antecedents of recycling intention – consumer awareness and perceived convenience. By incorporating other antecedents, like those proposed in the Theory of Planned Behaviour (attitude towards recycling and subjective norms), the conceptual model could be expanded or modified to improve its ability to predict behavioural intentions. Lastly, this study does not examine the influence of demographic factors, such as age, education, and gender, on the model's constructs. Future research could explore these demographic differences.

Despite these limitations, the study offers valuable contributions, as previously discussed. The research framework and findings are expected to inspire further investigations into e-waste recycling in the UAE and beyond.

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ACHIEVING SUSTAINABLE FREIGHT TRANSPORT IN VIETNAM USING EARNED RECOGNITION SCHEMES

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Purpose

The introduction of transport recognition schemes into ASEAN countries has been very limited to date, with voluntary schemes being more common in the geographical North. Although, there is evidence of some successful uptake in South American countries, which have allowed operators to develop records of compliance to operational standards, and evidence that their systems and processes promote sustainable, efficient transport management and reduce environmental impacts. Sustainable Logistics can be considered broadly as making freight transportation modes more sustainable by minimising environmental stressors and impacts (Ren et al, 2020). This research posits that introducing Operator Recognition Schemes in Vietnam helps towards addressing UN Sustainability Goals, specifically Goal 9: Industry, Innovation and Infrastructure and Goal 11: Sustainable Cities and Communities, through our adaptable framework to deliver Operations Innovation through testing four hypotheses:

H1: Are Operator Recognition Schemes viewed as a new concept in Vietnam?

H2: The characteristics of the Vietnam road freight market is a major contextual factor in designing processes for successful introduction of Vietnam recognition scheme(s).

H3: Vietnam's fragmented trucking industry represents significant barriers to future potential commercialisation of schemes.

H4: The collection of agreed metrics is important for managing recognition scheme(s) in contemporaneously monitoring its member progression to achieve defined objectives and increase sustainable logistics.

This research is both prescient and important; Vietnam's economic growth has remained relatively strong, its Gross Domestic Product (GDP) rose to 7.4% in 2019; although this has significantly fallen to 2.6% in 2021 (The World Bank in Vietnam, 2023) following the COVID pandemic, ongoing war in Ukraine, structural slowdown in China, and financial tightening in the U.S. which are all impacting on developing East Asia and Pacific (EAP)'s economic recovery. Vietnam's logistics performance however lags behind economic development. The annual report of the Logistics Performance Index (LPI) by the World Bank in 2023 indicated that Vietnam's LPI ranked 43rd, falling from 39th in 2018 among 160 ranked economies.

The Vietnamese government has announced an ambitious plan to reform its logistics sector - known as 'Decision No.200/QĐ-TTg'. This five fold action plan is intended to improve the competitiveness and development of Vietnam's logistics industry, which is expected to contribute 5-6% of GDP by 2025 (VCCI, 2021). To date, while actions have begun to improve infrastructure and customs, the missing piece of the puzzle is a mechanism to revamp logistics competence, tracking and tracing proficiency. This provides an opportunity for recognition schemes and to gather essential support from local authorities and freight transport operators. Further, the trend towards e-commerce in Vietnam continues to grow, which is reflected in the domestic road freight sector by increasing numbers of foreign forwarders, express service providers, retailers and startups (Dinh et al., 2017). This affords local government and industry the chance to allocate resources in the most efficient way, promoting good practice and adoption of greener technology to improve the road freight market. Over the last decade, most of the efforts in promoting sustainable freight transport in Asia fall under a sustainable development program or a climate change / environmental oriented project (e.g. Integrated Programme For Better Air Quality in Asia - Clean Air Asia, Regional Programme 'Cities - Environment - Transport' - The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Vietnam Coastal Cities Sustainable Environment Project - WB, etc.). The steering party of those supply chain initiatives are non-governmental organisations (NGOs) like Clean Air Asia, GIZ, ADB, World Bank, which are taking a progressively critical role in supply chain sustainability (Hyatt & Johnson, 2016). Unfortunately, the NGOs' conventional approaches which consider green freight as a trade-off between social and economic objectives has resulted in the limitation of these projects. The scope of those programs, therefore, is either limited in increasing environmental

awareness or promoting shipper's practices in green freight transport, neglecting the role of transportation service provider. However, Elkington's (1994) Triple Bottom Line model suggests that the freight sector could be an active contributor towards sustainable development. Such contributions from the freight sector could include, for example; improving routing and scheduling efficiencies which – in return, reduces overall logistics cost, energy consumption, emissions and thereby stimulates economic growth.

Literature Review

Transport Operator Membership schemes

As previously mentioned, the establishment of transport operator membership recognition schemes in ASEAN countries has been very limited to date; with such voluntary schemes being more commonplace in Western European countries, the UK, the USA, and with a small presence in Latin America. The only known scheme in Asia is 'Green Freight Asia' (GFA), which was implemented on inter-nation level with participants ranging from Association of South East Asian Nations (ASEAN) countries (Singapore, Vietnam, Laos, and Cambodia) to East Asian countries (Japan, China). Despite targeting both carriers and shippers, it is a modest program in terms of both number of members and brand awareness. The lack of essential authorities' support, a wide and complicated geographical range of target members, subscription model as well as early development state could account for the program's poor performance.

GFA adopts a comparable business model to the UK Fleet Operator Recognition Scheme (FORS) (FORS, 2023), which for a subscription fee offers three levels of accredited recognition: Bronze, Silver, Gold (Ballantyne & Heron, 2020). Similar to other established schemes such as Eco-Stars and FORS in Europe and the UK respectively (Ballantyne & Heron, 2020), the GFA assessment follows a fundamental process (submission of data, auditing and rewarding); and a similar rating system that uses green leaf labels; where one leaf recognises minimum commitment/adoption of green freight practices, to four leaves that recognises a sustainability leader with outstanding commitment/adoption of green practices (GFA, 2023).

Benefits and Barriers to scheme membership in Vietnam

By joining a transport operator recognition scheme, member organisations can demonstrate compliance with local regulations and policies, improve access to markets and customers, and reduce environmental stressors that are associated with freight transport operations. Blancas, et al. (2014) identified five major sources of unreliability in the Vietnamese logistic market, including cumbersome government regulations, the high incidence of facilitation payments, incomplete strategic transportation infrastructure plan, a fragmented trucking industry, and underutilization of the critical transportation infrastructure. These issues could be barriers to adopting recognition schemes. Without an inadequate barrier to entry, the trucking industry in Vietnam has fewer than 10 large sized operators, around 200 small to medium-sized companies, and the majority of the remaining carriers are single-truck operations (Blancas et al., 2014). Therefore convincing these MSME's of the benefits of joining recognition programs is challenging, with many possibly reluctant to commit to environmental targets or find membership fees unjustifiable.

In order to build up membership of such freight transport programs in Vietnam, there are four market characteristics and contexts (Dinh et al., 2017) which should be noted:

- 1) An improper licensing process leads to mediocre driver performances,
- 2) Fuel subsidy and lack of proper emission regulations provide zero incentive for operators to upgrade their fleet and maintain their equipment regularly (the average age of Vietnam's active trucking fleet is 17 years, which is much older than in Australia (14 years), Canada and Japan (9 years), U.K. (8 years), and U.S. and France (6-6.5 years), and thus truck breakdowns on highways are frequent.
- 3) Overloaded trucks are commonplace,
- 4) 35 percent of truck miles are empty.

However, the sector is heavily fragmented. With the top five by volume still only accounting for 6.2% of the market in a growing sector which accounted for 4.5% of Vietnam's GDP in 2022 across twelve segments of the sector.

Key Performance Indicators as Metrics for Sustainable Logistics

From an operational perspective, the foundation of most established transport operator schemes (as previously mentioned) that exist in the geographical north are key performance indicators (KPIs). The application and evaluation of KPI's through recognition schemes supports member companies to maintain customer focus and reach higher customer satisfaction (Sousa and Voss, 2002; Kaynak, 2003; Asif et al., 2013; Coimbra, 2013; Oakland, 2014). However, more broadly as a result of scheme compliance audits, KPI's enable recognition schemes to provide guidance in disseminating best practice to members by revisiting and modifying the indicators on a regular basis.

In the UK, the FORS scheme consists of 3 levels: Bronze, Silver and Gold, which focus on 4 key areas: Management, Vehicles, Drivers and Operations. Within each key area, there are subsections that will clearly define the requirement, its purpose, and details of what needs to be demonstrated to meet it. For example, the performance indicators required by the FORS scheme for Silver Members seeking upgrade to Gold Member (and included in FORS' basic requirements) are: Total usage and by distance travelled, Transport-related CO₂ by distance travelled, Transport-related NO_x and PM by distances travelled, Total incident and collision data and costs involving personal injury, vehicle or property damage, Total transport-related fines and charges. Whilst not these are not explicitly stated by Gunasekaran and Kobu (2007) on their list of 90 logistics and supply chain metrics many FORS standard performance indicators could be linked back. For instance, the operations key area requires a freight operator to conduct regular defect checks, and have specialists for goods and abnormal load could be translated back to the KPI of Conformance to specifications by Gunasekaran and Kobu.

Methodology

This research reviewed existing recognition and accreditation membership schemes in the global north including the UK, Europe and South America to identify best practices and potential for transferability to the Vietnamese context. A survey of 136 respondents including executives from both local and Foreign Direct Investment (FDI) companies in Vietnam was conducted and followed up with further in-depth interviews with concerned freight transport actors in Vietnam. These data collection activities have led to the development of a conceptual framework.

The foundation of this research is Total Quality Management (Deming, 1996) and Resource Based Theory (Grant, 1991). Based on Blaikie (2010)'s six sequential steps, this data triangulation enables the research to develop a range of hypotheses and research questions from existing literature. For example, work investigated the resource-based theory's statement that companies, through their continuous efforts to overcome their own limited resources and capabilities, are able to disrupt the market with their innovative advantages (Grant, 1991). Hence, they contribute to bringing down shipping costs across the entire supply chain, which benefits not only the companies themselves but the economy and public interest as well.

The Survey

A self-completion questionnaire survey was designed and distributed to identified mid to top-level managers in Vietnam's transport industry. Respondents were operational and strategic level executives in either road freight service providers or manufacturers operating a truck fleet. It consisted of 32 closed and 5 open questions, which has somewhat impacted the response rate with some respondents commenting it was too long, resulting in 96 out of 136 recorded responses being incomplete. The questionnaire was designed in two languages: Vietnamese and English, to help recruit a wider pool of participants and overcome any language barrier. The main focus of the questionnaire was the concept of recognition schemes. It also captured the fundamental information about respondents' organisations, which is highly beneficial for the construction of the adoption framework.

The questionnaire composed of 4 main parts linked to themes emerging from the literature review: General questions about the organisation, the concept of Recognition Schemes and TQM awareness. Most questions utilised a five-point Likert-type scale to calculate the level of agreement to the statement (Dawes, 2008), in this case the recording of either favourable or unfavourable standpoints towards the study (McDaniel, 2009). Some questions were designed to test the stated hypotheses, while others aimed to reassure and provide empirical evidence for the findings from the reviewed literature. The questions were also developed to reflect local contexts. For example, as the concept of Penalty Charge Notices (PCNs) – one of the main features in the UK FORS scheme does not exist in Vietnam, this identified scheme benefit was not included. A purposive sample of participants included operational and strategic level executives in either road freight service providers

or manufacturers operating a truck fleet. Initial respondents were in the author's professional network (former colleagues, industrial connections), who were asked to introduce others; which resulted in a homogenous sample, as the respondents were most likely to identify other potential respondents similar to themselves (Lee, 2000). The survey was distributed to 185 identified respondents with a response rate of 74.5 percent.

The interviews

The interview began with a series of open questions deducted directly from the findings in the survey, urging wide and developing answers from the interviewees. For example, "Which methods have been used to collect CO₂, NO_x, and PM reduction?" Probing questions were used to explore the locus of research emphasis on the focal points or focused directions. For instance, "Why did you think that controlling and reducing emissions are less important features than other features of a recognition scheme?" Similar to the design process of survey, close attention to the wording helped to avoid misleading, sensitive questions, jargon or over-encumbered theoretical concepts. The question guide and survey report were sent to the respondents one week prior to the scheduled interview.

After an initial call for interviewees, potential respondents were screened and interviewees selected based on initial criteria: seniority, experiences, current occupation. The target candidate was a seasoned manager with direct involvement in the management of the transportation operation in their organisation. Furthermore, the research targeted those who possess in-depth understanding about Vietnam's trucking market so that they could provide critical insights and justifications. These included a Branch Manager at a top-tier global third-party logistics provider in Vietnam, and a Project Manager for an emerging ecommerce company. The interviewees had experience with managing medium to large-sized truck fleets; and were familiar with regulations and practices in Vietnam's trucking market. Following the interviews, transcripts were returned to interviewees for correction and validation (Cayla and Arnould, 2013) prior to their analysis.

Findings and Originality

The research investigated four hypotheses to deliver operations innovation in Vietnam using transport operator recognition schemes. The results of this investigation are:

H1: Are Operator Recognition Schemes viewed as a new concept in Vietnam?

Despite the role of Green Freight Asia – this research concludes that the program does not show any significant footprint in Vietnam. A single organisation claimed to be a member of the GFA, but this was only as a marketing device to approach potential customers. Absence of support from local authorities as well as inappropriate design best described as 'adoption over adaptation', including missing translated documents, criteria adjustments for local conditions and a lack of scalability for smaller size organisation can partly explain the low awareness of GFA in Vietnam. The majority of Vietnamese operators do so within Vietnam's borders, therefore the potential benefits from a regional program like GFA have been limited. This finding naturally evokes the question of whether GFA can be modified to fit with local Vietnamese contexts and therefore, attract more members or an independent Vietnamese program could be more appropriate?

H2: The characteristics of the Vietnam road freight market is a major contextual factor in designing processes for successful introduction of Vietnam recognition scheme(s).

Vietnam is dominated by micro and small size truck operators in a free market which places cost-over-quality between the carriers in Vietnam. Additionally, the awareness of truck operator's responsibility for the alarming number of incidents, followed by "constant streams of accident reports on the media" and the "various researches by the Government and NGOs" can be leveraged as macro metrics of any adapted or newly established scheme. However, a diluted version of recognition schemes should be avoided at all costs. A Vietnamese scheme should go beyond providing a 'quality and safety certification', solely for the purpose of acquiring customers to fulfil the operating costs of a 'for profit' multi-national consulting organisation, whereby a Vietnamese scheme could potentially be compromised by imitation rather than innovation for the public good. A clear message should be addressed to its potential members, directing them to the long-term goal: optimal operation efficiency through continuous development. Additionally, other stakeholders should benefit from recognition

schemes too, as evidenced in the ECO Stars Fleet Recognition Scheme. The poor rating of GHG and PM reduction featured in the survey looms the threat over a scheme's efforts to promote better air and environment quality. There is a degree of reticence in that potential scheme members might be reluctant to commission environment-related actions. A possible explanation for this could be derived from a testimonial that truck operators "do not feel like they are the main contributor to air and environment pollution compared other sectors like manufacturing and construction". With an over-aging national truck fleet, they may find the cost of achieving environmental objectives extremely unattractive. Consequently, there should be "government incentives or more stringent regulations on CO2 emission" to attract "companies' attention in environmental problems".

H3: Vietnam's fragmented trucking industry represents significant barriers to future potential commercialisation of schemes.

The acceptance of a commercialised recognition schemes was found to be possible in the Vietnamese context, despite the fact that "the majority of the market player are competing on a small margin and sacrifice quality over the cost" (Blancas et al., 2014). A suggested average annual subscription fee was equal to the charge for a medium company to join a recognition scheme in a developed country like the UK. This supports the idea of establishing an independent and self-sustainable program in Vietnam where the cost for maintaining a similar scheme could be significantly lower (due to lower labour and rental costs etc.) This finding suggests that future recognition schemes could contribute to the progression of the market and sustainable development goals without being subsidised with Government financial aid. However, this should be concluded with caution, as the findings from a small sample size might not represent the market, especially with the absence of representatives from micro companies in the survey.

H4: The collection of agreed metrics is important for managing recognition scheme(s) in contemporaneously monitoring its member progression to achieve defined objectives and increase sustainable logistics,

The result of the survey about the current status of gathering KPIs has recorded a degree of progression of Vietnam companies. A majority of respondents are collecting the most basic performance indicators for fleet management. Another important finding was the shift of Vietnamese truck operators' concern from managing cost (fuel consumption) to increasing operational efficiency (volume utilisation and empty miles). The progression of collecting performance data could define the success of an organisation (Gunasekaran and Kobu, 2007; McKinnon, 2009). These findings suggest an open door for recognition schemes in Vietnam, in promoting and setting out agendas and objectives based on Key Performance Indicators. Moreover, the research identifies a common view amongst the respondents on the high importance of an industry standard. This consensus together with the status of collecting operation data and autonomously generated data suggests a potential role of recognition schemes in the Vietnam market. By KPIs collection, recognition schemes could act as a mediator between policy makers, legislators and operators, LSPs as well as carriers in updating and reviewing the customised KPIs for Vietnam's current market condition (McKinnon, 2009). When it comes to this role, the major difference between recognition programs and trucking associations originates from its independent relation with the main stakeholder – truck operators. Besides, it could benefit other stakeholders including shippers, insurers and manufacturers by providing evaluation criteria for supplier selection as well as reviewing tools for annual supplier evaluation and development programs. Additionally, thanks to live data and demonstration of the progression towards environment and safety objectives, the public stakeholders could have a better understanding of the trucking industry as well as its impact on the environment, sustainability and daily life.

Conclusions

The vast majority of freight transport operators in Vietnam are categorised as Micro, Small and Medium Sized enterprises (MSMEs) and therefore cannot overhead immediate and unplanned expenditure for cleaner / less environmentally impactful assets. Therefore there are opportunities for organisations to improve their fleet management through processes designed to deliver better loading/planning/routing, whilst also ensuring that they can benefit from compliance with recognition schemes. Such schemes however require colleague 'buy-in' and strategic onboarding so that robust, benchmarked processes can drive compliance, improve sustainability, and ensure the retention of both colleagues and customers. Whilst evidence continues to emerge relating to reshoring and near-shoring, there will remain strong economic reasons to offshore certain types of production and import raw materials from producer nations. However, if we export commodity production then there is an opportunity to export good practice for freight transport sectors supporting manufacturing and customer fulfilment, thus allowing for migration of best practices across multiple segments in that particular home market too. Our findings have allowed us to develop the following conceptual framework:

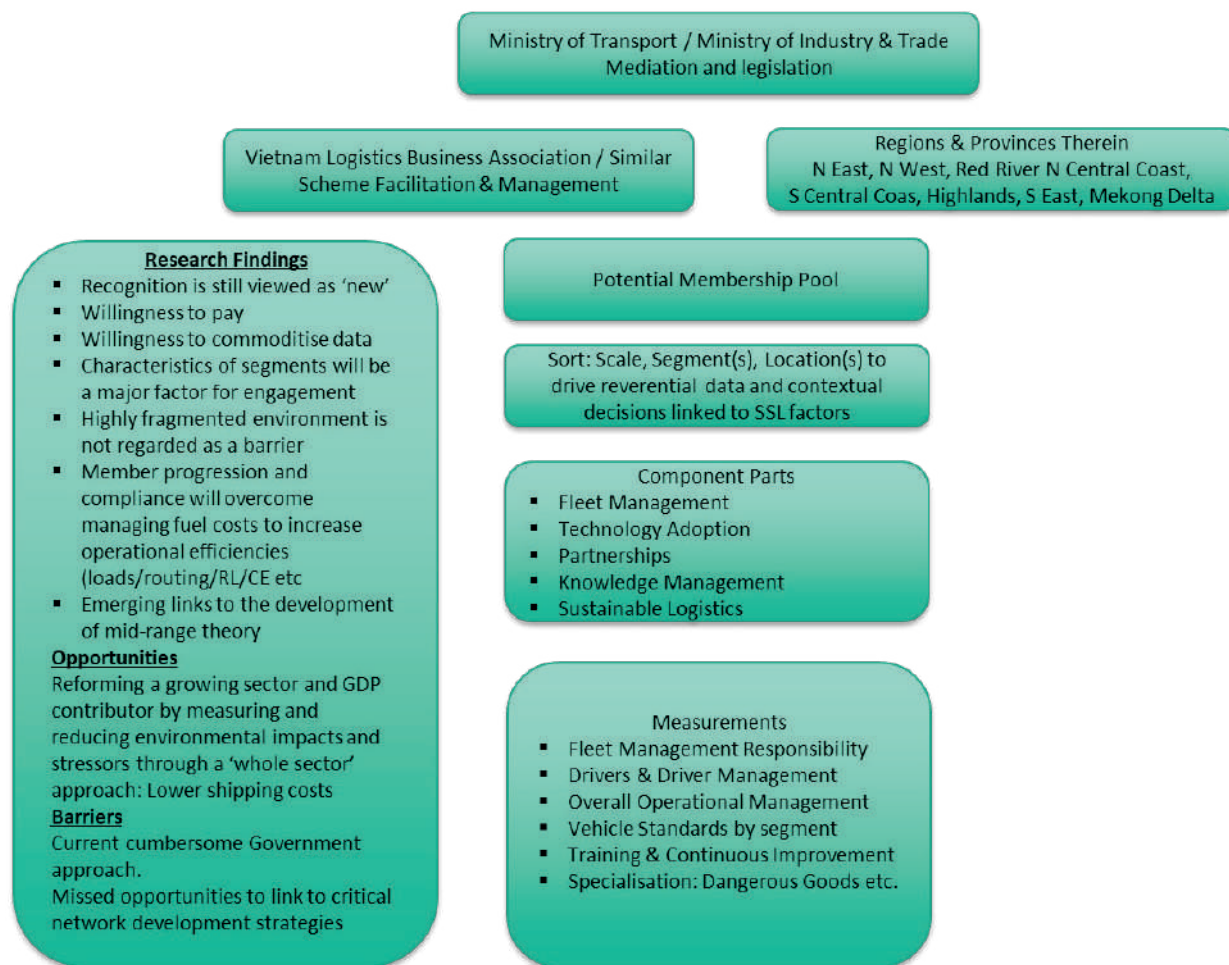


Figure 1 Conceptual framework for Vietnamese transport operator scheme membership (Source: Authors)

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CUSTOMER-DRIVEN SUSTAINABLE FOOD RETAILING – A FRAMEWORK FOR GAP ANALYSIS

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Purpose: Food retailing operations are one of the significant sources of energy, water, and packaging-related materials consumption. Such high level of resources consumptions and alarming level of food waste is linked to global warming, natural resource scarcity, biodiversity, and global food security. While sustainable operations are already in place, there is still little understanding of whether and how the end consumers' sustainability preferences play a role to redesign the existing sustainable operations. Given the growing level of public awareness of global warming, the end consumers' expectation of sustainability has been increased considerably more than ever before. Hence, the research aims to understand whether and how any gap between the intensity of consumers' preference for sustainability and the actual sustainability practices being adopted in the food retailing sector in the UK.

Research approach: In the first stage, a survey was conducted among the end consumers who frequently shop from mainstream food retailers in London. 100 responses were collected to understand the level of sustainability preferences while buying food items. In the second stage, a semi-structured interview was conducted with 8 operations managers from the mainstream UK food retailers followed by analysing 8 sustainability reports. A data triangulation approach was taken to develop the final framework of sustainable food retailing.

Findings and originality: The results indicate that consumers showed a high level of preference for recycling, eco-friendly packaging, and energy reduction-related practices. In response to these preferences, the retailers adopted the relevant practices between medium to high levels. Interestingly, while the retailers pay high-level focus on sustainability logos (e.g., fair trade, rainforest alliance etc), the consumers showed low to medium level preference for it apart from recycling and carbon footprint labelling. Given almost equal importance, packaging, sourcing, and food waste reduction were identified as the topmost sustainability criteria by the consumers while retailers exceeded consumers expectations on both food waste reduction and ethical sourcing. Though the consumers showed a high level of preference to buy from those retailers who motivate the consumers to bring their own bags for shopping, the retailers have been sought to take low levels of such actions (e.g., awareness programs). It is the first research that identifies the gaps between consumers' sustainability preferences and the actual practices being adopted by food retailers in the UK context.

Research impact: There is little evidence on how to identify, prioritise and address sustainability-related practices based on end consumers' preferences for buying a food item. The study also enhances the existing knowledge on why and how end consumers can become a strong driver of sustainability practices in the food retail sector.

Practical impact: The research results can influence the food retailers in the context to redesign the operational level sustainability strategies and related practices to satisfy the end consumers' expectation. It also can help the local NGOs (e.g., WRAP - Waste and Resources Action Program) to take the necessary actions in collaboration with the food retailers.

Keywords: Sustainability, Food retailing operations, consumers' sustainability preference.

1. Introduction

According to a report by the Food and Agricultural Organization of the United Nations, approximately one-third of the food produced worldwide is either wasted or lost (FAO, 2017). Food retailing and consumptions has been identified as one of the crucial phases to reduce food wastes by halve by 2030 to deal with such global crisis (Ishangulyyev et al., 2019). Though the food wastes in actual consumption phase is almost 29 times higher than retail operations (WRAP, 2017), the retailers have just recently realised that they can play a crucial role to promote sustainable consumption (Rosenlund et al., 2020). Food

retailing operations are also significant sources of water and energy consumptions. For instance, in the UK, 20% of total energy used in 2011 was consumed by the retail stores (Kolokotroni et al., 2015). The annual rate of food packaging wastes has grown by 4.2% in EU since 2010 and expected to continue at the same rate till 2024, where plastics materials were still predominant in the market by almost 50% in 2015 (Ketelsen et al., 2020).

As waste generation and energy consumption soars, sustainable food retailing has emerged as a vital tool in retail (Widlitz, 2020). Most importantly, customer awareness of food wastage and sustainable purchasing is thought to be the only key to sustainable food retailing. According to a recent Mintel report 80% of consumers surveyed have tried to reduce food and drink waste in the past year (Carroll, 2022). Additionally, nearly four in five (79%) UK consumers would choose to buy products with a sustainability claim (Goode, 2023).

Given such socio-political pressure for sustainable products, food retailers have already adopted several practices such as green energy, reduce packaging wastes via recycling, food waste reduction via food donation, waste valorisation, water reduction, eco labelling, fair trade, local sourcing, promoting plant based healthy food, etc (Rosenlund et al., 2020; Huang et al., 2021; Samoggia et al., 2019; Sogn-Grundvag et al., 2019, etc). Some non-governmental organizations efforts were also evident. Such as WRAP in the UK has been promoting wastes reduction and related other sustainability practices for food retailers to achieve carbon reduction goal and create a circular economy.

Interestingly, while such sustainable operations are already in place to a variety of extent across different contexts, there is still little understanding of whether and how the end consumers' sustainability preferences play a role to redesign the existing sustainable operations (Liu et al., 2012; Tang et al., 2016). Given the growing level of public awareness of climate change, the end consumers' expectation of having sustainable products has increased considerably more than ever before. It is crucial to consider and incorporate consumers' sustainability preferences and retailers' sustainable practices into a framework that allows for optimal sustainable food retailing. Therefore, a clear framework for gap analysis between 'the sustainability expectation from consumers' and 'the actual adoption level of sustainability practices employed by the retailers' is crucial.

The UK food and drink sector is the largest manufacturing sector in the UK, contributing more to the economy than other manufacturing factors (FDF, 2022). However, the industry faces sustainability challenges as a result of the cost-of-living crisis and confusion over the product green credentials (Goode, 2023). To our knowledge, there has been little research from the UK to provide an understanding of the differences between consumers and retailers when it comes to food-related sustainability practices (Van Bussel et al., 2022).

In this research, we aimed to investigate sustainable food-retail management practices and customer expectations of sustainable food retailing in the United Kingdom and to offer a framework for retailers to help redesign the sustainable food management system considering consumer preferences.

The three main objectives of this study are:

- To understand end consumers' preferences of sustainability that affects purchasing decisions in the UK food retailing sector.
- To explore sustainable retail management practices in the UK food retail sector.
- To provide a framework for the UK food retailing sector to improve sustainable retail management practices considering the end consumers' expectations.

The paper starts with a brief literature review of sustainable food retail management followed by a research approach of data collection and analysis methods. It concluded with a discussion and a framework on customer-driven sustainable food retailing for retailers.

2. Literature review

2.1 Sustainable food retail management

Sustainability in the food retailing sector refers to managing a business in such a way that negative effects of retail operations on the environment, society, and the economy are minimised while positive effects are maximised (Rosenlund et al., 2020).

While reviewing the existing works, a wide range of sustainability activities and management practices were identified. For instance, according to prior studies (Huang et al., 2021; Rosenlund et al., 2020; Papargyropoulou et al., 2022) and sustainability reports from different retailers (e.g., Tesco, Lidl, Waitrose etc), food waste reduction practices by the grocery retailers can be categorised into four main areas including (a) donation and redistribution, (b) discounting (of products close to expire), (c) compost or convert foods to energy, (d) sensor technology for shelf temperature management.

Sourcing sustainable ingredients and resources is the top priorities for these UK food retailers. They collaborate and work closely with their suppliers, farmers, and workers to ensure responsible and ethical sourcing and animal health and welfare. Food retailers are taking steps to support and launch initiatives to ethical sourcing of food and/or food ingredients (Mboga, 2017). For example, Morrisons commits to source “Red tractor assured” meat, sustainable palm oil and soya through a certified supply chain system that does not contribute to deforestation (Morrison, 2021).

To reduce plastic packaging, food manufacturers and retailers are also aiming to switch to new packaging that utilises biodegradable materials such as compostable biopolymer (Meeks et al., 2015). Reduce, reuse, and recycle are widespread practices among UK food retailers (TESCO, 2023; Waitrose, 2023). To improve energy and water footprint the retailers have been taking wide range of energy efficiency measures and energy-efficient technologies adoption in conjunction with sustainable water management systems (Naidoo and Gasparatos, 2018).

2.2 Consumer preferences on sustainable retailing

Though there is growing evidence of consumer preferences for sustainable retailing, little is known whether and how the retailers meet such preferences while adopting sustainability practices. Fromm (2020) highlights that 65% of customers look for goods that will make their lives more sustainable. A study in 28 countries found that 80% of consumers believe sustainability is important and 70% of them are willing to pay premium for sustainable product and change their purchasing habits to decrease the negative environmental impact (Widlitz, 2020). Data from 428 UK supermarket shoppers also previously revealed that 72% of them demanded food with carbon labels (Gadema and Oglethorpe, 2011). Interestingly, it has been also found that consumers still lack a fundamental understanding on the connection between ‘sustainability’ and ‘food choices’, though they have a high-level understanding on environmental impact, local and organic food choice, and ethical production (Van Bussel et al., 2022; De Canio, 2021)

3. Methodology

Given the nature of query we have adopted a mixed methods approach to develop a sustainability gaps framework. Such approach enriched the validity and reliability of research findings (Creswell, 2013). As the initial aim was to get a snapshot on the extent of expectation on several sustainability practices (e.g., green labelling, recycling, waste reduction, carbon footprint, fairtrade, etc) by the consumers, a survey was valid choice. The survey items were developed from the previous studies such as (Van Bussel, 2022; Ketelsen et al., 2020; De Canio, 2021, etc) and in consultation with some operations managers within the participated retailers. The survey was conducted primarily in London due to researchers’ convenience and its cultural and socio-economic diversity. It covered the shoppers from 8 mainstream food retailers. Both random and convenience approaches were taken to collect responses to reach wider demography. In total 100 responses were finally analysed using simple non-inferential statistics.

Once we had a quick picture on the extent of sustainability preferences by consumers across different parameters outlined above, we then explored via semi-structured interview whether, what and how different sustainability practices adopted by those 8 retailers we surveyed. Such approach helped us to understand the sustainability practices adopted by the retailers. The operations managers or retail store managers were recruited for interview. The data were collected from 8 managers. As majority of the managers referred the sustainability report published by their company, we also analysed those respected (8 of them) reports. The sample size for both interview and sustainability reports were justified in line with data repeatability, data accuracy, data sufficiency, data quality and quantity (Fusch and Ness, 2015) to address the proposed research objectives. Combining both interview and sustainability reports a holistic subjective approach was taken to rate (low / medium / high) (Balasubramanian et al., 2021) relevant sustainability practices employed by the retailers.

4. Findings and Discussion:

The survey reveals that consumers has showed a high level of preference for recycling, reusing, eco-friendly packaging, and energy reduction-related practices. Fig. 1 shows the key sustainability preferences by the consumers. In line with these preferences, the retailers adopted relevant sustainability practices between medium to high levels as revealed by the interview and sustainability reports analysis. For instance, the retailers manage wastes via two mainstream practices such as plastic packaging reduction (e.g., recycling centre, in-store collection, recyclable and reusable materials, less plastics use etc) and food wastes reduction (e.g., discount, charity and food banks, segregation of edible and nonedible items etc).

We have taken a holistic approach (based on data triangulation) to understand whether and how the existing sustainability practices employed by the retailers meet the consumers expectation on the important sustainability activities and practices. Such approach leads us to develop a sustainability gaps framework (see Table 1). The framework indicates the retailers' current position to satisfy the consumers' sustainability expectation. For instance, while retailers place a high-level focus on sustainability logos (e.g., fair trade, rainforest alliance, etc.), consumers have a low to medium level preference for them apart from recycling and carbon footprint labelling. This is probably due to the lower level of awareness of such logo and related sustainability benefits (Gadema and Oglethorpe, 2011; De Canio, 2021). Though consumers expressed a high level of preference to buy from those retailers who encourage them to bring their own shopping bags, retailers have implemented only a limited number of such actions (e.g., awareness programs). It raises concerns that the retailers have failed to meet consumers expectations on eco-friendly packaging, renewable energy, carbon footprint labelling, and eco food logo.

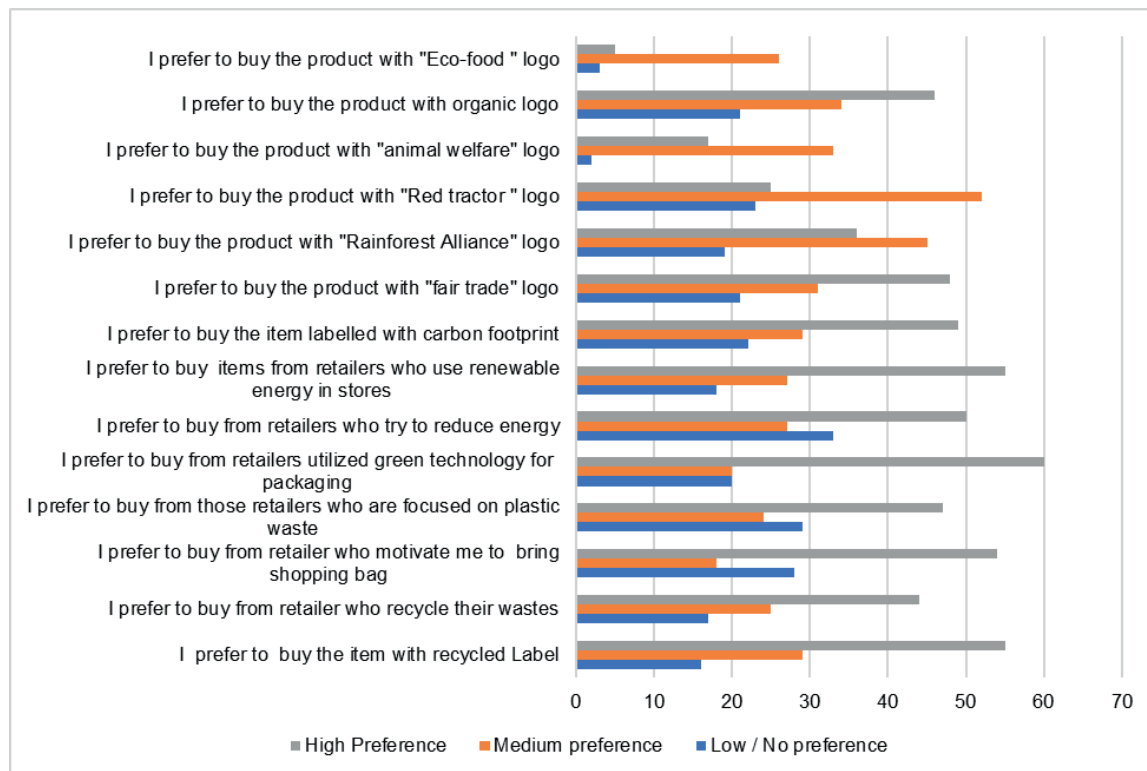


Fig. 1. Consumer preferences over sustainable food retailing (source: survey)

Consumer sustainability preference or expectation	Extent of expectation or preference	Sustainability gaps (+/0/-)	Extent of adoption of relevant practices	Relevant sustainability activities / practices adopted by retailers
Waste recycling	3	0	3	e.g., composting, collect plastics bags and containers for recycling; segregation etc
Reduce plastic wastes	3	0	3	e.g., plastic free packaging; reusable paper bags, wooden spoon, remove plastic trays from fruits
Eco-friendly packaging	3	-	2	e.g., bio-degradable packaging
Energy reduction	3	0	3	e.g., LED light, centralised heating, energy efficient fridge
Renewable energy	3	-	2	e.g., electricity from renewable sources
Carbon footprint label	3	-	2	e.g., supplier certification
Recycle label	3	0	3	e.g., supplier certification
Promote reuse of shopping bag	3	-	1	e.g., communication to promote reuse
Fair trade logo	3	0	3	e.g., strategic supplier partnership for certification, code of conduct
Rainforest alliance logo	2	+	3	
Red Tractor logo	2	+	3	
Animal welfare logo	2	+	3	
Organic logo	3	0	3	
Eco-food logo	2	-	1	
Plant-based food	3	0	3	e.g., social media promotion
Low Packaging	2	0	2	e.g., reduce packaging requirements; packing free delivery;
Consumer sustainability preference or expectation	Extent of expectation or preference	Sustainability gaps (+/0/-)	Extent of adoption of relevant practices	Relevant sustainability activities / practices adopted by retailers
Ethical Sourcing	2	+	3	e.g., local sourcing; supplier collaboration and certification, code of conduct
Food waste reduction	2	+	3	e.g., charity and food bank; discounting; waste valorisation etc

Table 1: Sustainability gaps framework (source: data triangulations based on survey, interview, and sustainability reports)
[N.B: 1 = low / no; 2 = Medium; 3 = High; + (positive) is above consumer expectation; - (negative) is below consumer expectation; and 0 (zero) meets consumer expectations]

5. Conclusion

The findings of this study offer a sustainability gaps framework for redesigning and regulating sustainable practices for the food retailers working with suppliers and consumers. Such simple framework could be used as a tool for the operations managers to assess the existing sustainability practices against growing consumer expectation. Based on such gap analysis the top management can also guide and support the operations to ensure the relevant resources are in place to meet customer expectation. The WRAP can also use the tool in liaison with the retail industry leaders to see if any specific actions or awareness program (e.g., promote carbon footprint labelling, biodegradable packaging, educate consumers on sustainability logo etc) required to achieve the UK's carbon reduction goal of 80% by 2050 from the base year of 2010.

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DECARBONIZING ROAD FREIGHT TRANSPORT – A SYSTEMATIC LITERATURE REVIEW ON THE HAULIER'S PERSPECTIVE

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Introduction

The transport industry has long worked with different kinds of green practices, especially with those that go hand in hand with cost reductions such as truck and fuel efficiency measures as well as transport efficiency. In recent years, new technologies such as renewable fuels and electrification have become more mature for usage in trucks and they are seen as a contributor to substantially reduce emissions from transport activities. In Sweden, there are so far over 15,000 electric light-duty trucks (about 2 percent) and 340 (about 2 per mille) electric heavy-duty trucks with numbers continuously rising. However, deployment needs to be accelerated in order to meet climate targets. At the same time, the transition away from fossil fuels is a great leap: Apart from incremental changes, the transport industry has worked in the same routines for decades and within a transport system with stable features, e.g. relying on an established refueling infrastructure and known vehicle performance. How literature so far has caught freight transport actors' perspectives in this challenging transition is of importance in order to identify areas that require investigation with the ultimate aim to accelerate up-take of new technology by these actors and consequently reduce greenhouse-gas emissions. In this paper, we present a systematic literature review (SLR) focusing on the road haulier's perspective. Road hauliers have an important role to play in this transition as their ability to change, invest in vehicles and develop their competence are central to how fast the transition can progress. Therefore, it is of interest to assess what is known about them and their perspective. The purpose of this paper is, therefore, to investigate the role of hauliers in the literature dealing with decarbonizing road freight transport, especially with focus on electrification. The literature review was guided by the following research question:

- How have road hauliers' and related logistics actors' perspectives been included in literature when it comes to freight transport electrification?

In our understanding, hauliers as a group of actors can be described as the core of the road freight transport system as they both perform the physical transport and own transport resources, i.e. vehicles. The majority of hauliers are small companies owning a few trucks and often serve as subcontractors to larger freight forwarders or logistics service providers (LSPs). In literature, the term LSP or freight forwarder sometimes includes hauliers and no clear distinction is made between them. In this paper, we will make this distinction and focus on the haulier's dedicated role in the transport system, which is physical transport and vehicle ownership. It is the definition of the haulier's role rather than the term "haulier" itself that forms the basis for how we conducted our literature search.

Method

This study is based on a systematic literature review which took inspiration from Sandberg et al. (2021) and was conducted in three overall steps: 1.) objective and search strings, 2.) location of literature and selection, 3.) analysis of article content. In relation to the research question, our search strings included two dimensions: the activity that reduces carbon emissions, e.g. electrification, and the actor perspective, e.g. hauliers. Building the search strings was a learning process and they were iterated over time to catch different aspects of the topic. A search string could then look like this: [*Electrif* OR battery OR BEV] AND [haulier* OR trucking OR trucker* OR forwarder OR 3PL OR LSP OR TPL OR "logistics compan*" OR "Third party logistics" OR "Logistics service provider*"]. In addition to usage of search strings, we applied a complementary search

including literature recommendations from peer researchers, from previous research work, as well as a snowball approach. The database used for finding articles was SCOPUS. Several rounds of selection against inclusion /exclusion criteria were done, each round including at least two researchers in order to increase the quality of the process (Snyder, 2019). The selection process of the study is illustrated in Figure 1. Our inclusion criteria reflect the two dimensions of our search strings: A paper needed to relate to environmental sustainability on the one hand and must have a clear actor perspective on the other hand in order to qualify for inclusion. Actor perspective for us defines as the actor in question (hauliers or their function) being included empirically, e.g. through surveys or interviews, or through researchers collaborating with the actor, e.g. to provide a realistic and fitted solution.

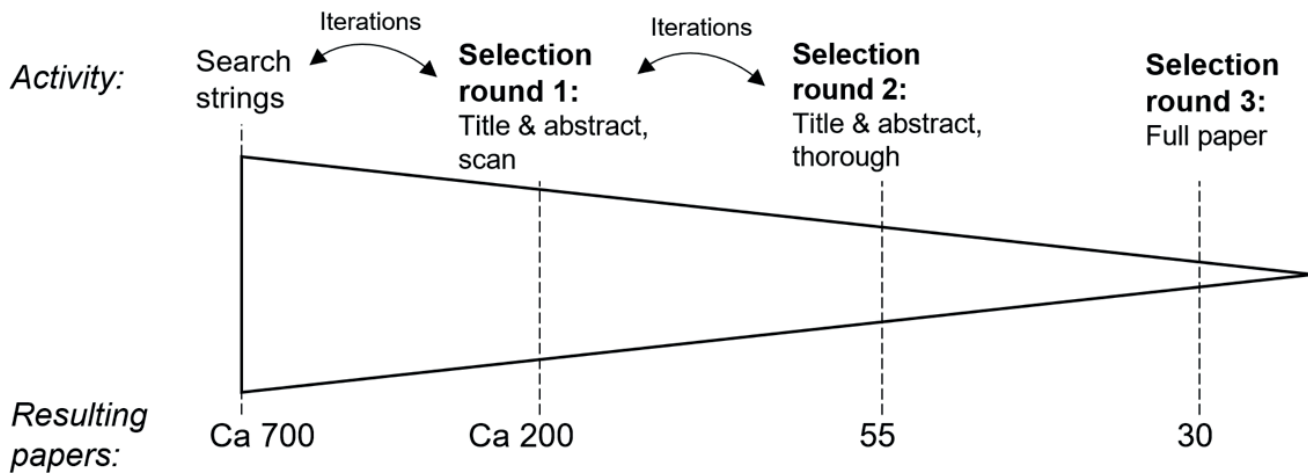


Figure 1 - Selection process of the SLR

A discovery from the first selection round was that the large bulk of literature found on electrification is of quantitative nature, especially mathematical modelling of for example routing for mixed fleets, or for vehicle charging. These papers present results that can be relevant for hauliers and their decision making, however, they largely lack perceptions or reflections from hauliers or other logistics actors on the modelling approaches and solutions offered and were therefore excluded from this review, with the exception of two papers (Moll et al., 2020; Van Duin et al., 2013) which create their model by consulting with the potential user. Analysis was done by extracting certain comparable information from each paper as well as by identifying overarching or repeating themes in the papers.

Literature overview

To our knowledge there are no other systematic literature reviews covering the haulier's unique perspective when it comes to decarbonizing freight transport. There are some literature reviews covering the freight forwarder's perspective in environmental sustainability, of which the most recent ones are Evangelista et al. (2018) and Centobelli et al. (2017). In their review, Centobelli et al. (2017) focus on logistics service providers and the third-party logistics sector where transportation is included as one amongst several services and activities. Evangelista et al. (2018) provide a definition of 3PLs that implies inclusion of hauliers in certain cases and have included them in their search string. Nevertheless, aspects relevant for hauliers in these reviews are only one amongst several. As the haulier's business differs notably from 3PLs or freight forwarders they deserve a dedicated review. Additionally, electrification is not discussed in the aforementioned review papers. We found one review on fuel-cell heavy duty trucks which does not take any specific focus on any type of actors but results touch logistics actors (Camacho et al., 2022).

Relevant papers included for analysis range between the years 2009 and 2023. Half of all papers were published 2020 or later, especially papers about electrification are on average younger than papers on other green practices. There is a fair share of papers concerning electrification (14) versus other green practices (17). Both quantitative and qualitative methods are represented, with slightly more qualitative studies (17 of 30). Quantitative studies mainly consist of surveys, but also a few models, while qualitative studies mainly use interviews and case studies. Most studies published were conducted in Europe (24 of 30) of which many in a Nordic context (12). Studies in the Americas counted to 5, and one study was conducted in New Zealand. There is a notable absence of Asian studies.

Analysis of the literature

The analysis for this paper is divided into two parts. First, the papers are analyzed in terms of the actor perspective. In the second part, the papers are analyzed with respect to the emission reduction strategy: electrification and other green practices.

Actor perspective

Most studies included in this review cover several different actors' perspectives simultaneously such as hauliers, LSPs, OEMs, shippers or policy makers. Terms for the different logistics actors are not used in a straight-forward way. The term haulier, for example, is only one amongst many terms utilized, which made analysis of the papers challenging. Common terms are road carrier, trucking company, owner-operator, commercial fleet operator, transport operator, and hauliers can be included in the umbrella term of logistics service provider. Therefore, a clear definition of the haulier's features and role in the logistics system was necessary, which for us includes companies owning their trucks and focusing on the physical transportation. This definition means that even some papers taking an LSP's perspective were relevant for our understanding of hauliers because these papers focused on the physical transport and vehicle ownership as opposed to other logistics services offered by LSPs (e.g. Küffner, 2022; Van Duin et al., 2013).

We found sixteen studies which focus on hauliers as the central actor of interest and either exclusively collect empirics from them (Caspersen et al., 2023; Letkiewicz et al., 2022; Pöllänen et al., 2021; Cantillo et al., 2022; Pöllänen et al., 2022; Frenzel et al., 2021; Jovanovic et al., 2020; Lebeau et al., 2016; Islam and Olsen, 2014; Liimatainen et al., 2014; Thornton et al., 2009), or in those cases where other actors are included this was mainly done to better understand hauliers and their context (Björner Brauer and Khan, 2021; Morganti and Browne, 2018; Quak et al., 2016a; Behrends, 2015; Arvidsson et al., 2013). However, in several papers hauliers are not of central focus, being merely one among several different actors investigated or they are investigated to better understand another central actor (e.g. Lind and Melander, 2023; Stelling and Brunner, 2023; Takman and Andersson-Sköld, 2021; Hovi et al., 2020; Nilsson et al., 2017; Seitz et al., 2015). In most of these papers it is unclear which opinion belongs to hauliers as different actors' opinions are lumped together (such as in Stelling and Brunner, 2023; Takman and Andersson-Sköld, 2021; Hovi et al., 2020). Respondents from the hauliers were mainly managers or owners and in some cases truck drivers.

As electrification was of main interest for this review, it is interesting to mention that only five electrification papers take their main interest in hauliers (Cantillo et al., 2022; Pöllänen et al., 2022; Morganti and Browne, 2018; Lebeau et al., 2016; Quak et al., 2016a) of which two only touch electrification marginally and in combination with other topics: automation and renewable fuels (Cantillo et al., 2022; Pöllänen et al., 2022). This leaves us with three papers with a core in both electrification and hauliers: Morganti and Browne (2018); Lebeau et al. (2016) and Quak et al. (2016a). These will be described further in the next section. Morganti and Browne (2018) included operators' fleets ranging from small to large. Lebeau et al. (2016) focused on small companies.

Electrification versus other green practices

Most of the papers concerning hauliers and electrification cover battery electric vehicles (BEV) (Küffner, 2022; Cantillo et al., 2022; Fenton and Kailas, 2021; Hovi et al., 2020; Moll et al., 2020; Morganti and Browne, 2018; Lebeau et al., 2016; Quak et al., 2016a; Quak et al., 2016b; Taefi et al., 2016; Van Duin et al., 2013). Küffner (2022) is the only paper which includes logistics actors' perspectives when it comes to hydrogen and fuel-cells. We have not found any studies on electric road systems or battery-swapping that provide insight into logistics actors' perceptions of these solutions. Similarly, most papers have so far focused on urban or short distance freight transport (Hovi et al., 2020; Moll et al., 2020; Morganti and Browne, 2018; Lebeau et al., 2016; Quak et al., 2016a; Quak et al., 2016b; Taefi et al., 2016; Van Duin et al., 2013). Only one paper covers more regional transportation (Fenton and Kailas, 2021). This is not entirely surprising, as BEVs are most technically mature amongst the different electrification technologies and their first application has been in an urban context making it possible to collect for example early adopters' experiences with these vehicles. However, this does not fully explain the absence of studies of less mature technologies or other applications. As Küffner (2022) shows, it is fully possible and even important to investigate less mature technologies in order to highlight different actors' perspectives.

Some of the papers on electrification describe factors that influence decision making of specific actors such as hauliers and other logistics actors in the shift towards electrification, for example enablers, barriers or incentives (such as policies), strengths and weaknesses, as well as perceptions of technologies, i.e. factors that are relevant for vehicle owners to consider before a vehicle is purchased (Cantillo et al., 2022; Küffner, 2022; Pöllänen et al., 2022; Morganti and Browne, 2018; Lebeau et al., 2016; Quak et al., 2016a; Quak et al., 2016b; Taefi et al., 2016). Complimentary to this, several studies investigate experiences with already implemented vehicles, both positive and negative, such as challenges or lessons learned (Stelling and Brunner, 2023; Fenton and Kailas, 2021; Hovi et al., 2020; Morganti and Browne, 2018; Quak et al., 2016a; Quak et al., 2016b; Taefi et al., 2016). The importance of the ecosystem and the diverse actor relations that are required for these new technologies and their implementation is recognized by Stelling and Brunner (2023), Küffner (2022) and Fenton and Kailas (2021). Only three of the above studies have both electrification and haulier's perspective at their core: Lebeau et al. (2016) focus on urban freight transport companies' preferences and vehicle choice behavior through a conjoint-based choice analysis, a survey-based method. Their sample consists of mainly small firms, highlighting the trade-offs these companies face when choosing vehicles, for example related to costs, operational aspects and performance. Policy support is one advocated solution and the article gives policy suggestions to best stimulate BEV adoption based on the findings. Even Quak et al. (2016a) analyze carriers attitudes towards EVs in a city logistics context by conducting a survey. The authors highlight the challenges for a functioning business case using electric vehicles. Morganti and Browne (2018) investigate last-mile operators' perceptions and acceptance of EVs through interviews. Focus lies on technical and operational barriers and how these may be overcome, for example using different policy incentives. Summarizing, all three studies are conducted in an urban or last-mile context. Additionally, these studies are comparably old given recent developments in battery technology, cost reductions and new application possibilities for electric vehicles, and it is surprising that there do not appear to be any newer studies. Academic literature usually is delayed and especially with the current pace of developments in electrification literature may lie well behind actual happenings in the real world. However, this does not fully explain the absence of studies.

Most literature with haulier perspective on other green practices covers general environmental sustainability or environmental performance (Letkiewicz et al., 2022; Pöllänen et al., 2021; Jovanovic et al., 2020; Nilsson et al., 2017; Thornton et al., 2009). For example, Pöllänen et al. (2021) analyze the development of environmental practices and the awareness of hauliers to such practices. In addition, there are many papers that focus on specific green practices, including the use of alternative fuels (Cantillo et al., 2022; Björner Brauer and Khan, 2021; Frenzel et al., 2021; Takman and Andersson-Sköld, 2021; Seitz et al., 2015), transport efficiency practices (Caspersen et al., 2023; Islam and Olsen, 2014; Arvidsson et al., 2013), energy efficiency practices (Liimatainen et al., 2014), and fleet modernization (Turner and Thompson, 2023) as well as modal shift (Behrends, 2015). There are also some papers that combine different green practices (Jovanovic et al., 2020; Tacken, Rodrigues and Mason, 2014). Similar to electrification, literature on green practices has focused on different factors that influence decision making of hauliers for implementing green practices. This includes drivers (such as customer requirements) and incentives (such as policies), attitudes and perceptions, as well as barriers (Turner and Thompson, 2023; Cantillo et al., 2022; Letkiewicz et al., 2022; Frenzel et al., 2021; Pöllänen et al., 2021; Islam and Olsen, 2014). Especially, barriers for implementing green practices among hauliers are emphasized. Such barriers include technical barriers, lack of knowledge of environmental practices, lack of collaboration among hauliers and other actors, as well as poor infrastructure for alternative fuels and lack of financial incentives from regulators.

Conclusions

The paper contributes to existing research by investigating the haulier's perspective in terms of decarbonization of road freight transport in general, and electrification in particular. Based on this we provide suggestions for future research. Results of our review point to a lack of haulier perspective in the literature when it comes to both electrification and other emission reduction strategies. Only eleven studies fit the core of our study which focusses on electrification, i.e. studies which have focused specifically on hauliers and collected empirics from them when it comes to electrification. Studies with hauliers as sole focus are even more scarce. There is literature which takes hauliers' views when it comes to other types of sustainable practices such as alternative fuels, transport and energy efficiency, or modal shift. However, the literature is scattered and in neither area more than a handful of papers were found. Many papers included in this review focus on more than one type of actor, e.g. including different logistics actors and other stakeholders such as LSPs, OEMs, shippers or policy makers. In some of these hauliers' views have been lumped together with other actors' views and cannot be distinguished anymore. To conclude, the voices of hauliers are not often heard in literature. Coverage of their perspective is sometimes implied when investigating the perspective of other logistics actors such as LSPs, even though hauliers have a different business and

position within the logistics' system. Therefore, a main takeaway from this review is the need for more research on hauliers and their perspective in the transition towards fossil-free transport operations. Hauliers and even other logistics actors' absence is especially obvious when it comes to other electrification technologies than BEV such as electric road systems, or hydrogen powered freight transport. Literature can also be expanded beyond urban and last-mile contexts. Even other logistics actors' perspectives, such as LSPs, are scarce in literature when it comes to electrification. Of course, academic literature usually is delayed and especially with current pace of developments in electrification literature may lie well behind actual happenings in the real world, e.g. many ongoing pilot projects in which hauliers and other logistics actors' perspectives are likely being included. Such ongoing studies provide opportunities to study electrification and hauliers academically.

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ENABLING SUSTAINABLE URBAN FREIGHT LOGISTICS- A STAKEHOLDER PERSPECTIVE

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1. Introduction

The purpose of this study is to develop a transitional framework that can be used by major stakeholders of urban freight, particularly logistics service providers (LSPs) and public policymaking bodies (PPBs) to formulate and an implement freight environmentally sustainable urban logistics (ESUL) practice.

With the increasing demand for urban freight logistics, all stakeholders of the urban ecosystem- shippers, receivers, LSPs, and customers including local businesses are challenged to reduce negative environmental externalities in their operations (Kiba-Janiak, 2017; Macharis et al., 2014; Muñoz-Villamizar et al., 2020). Sustainable solutions to urban freight logistics include efficient vehicle route planning, sharing resources wherever possible, and the adoption of low or zero-emission vehicles to reduce emission factors (Kumar, 2021). The challenges that arise here are often related to data sharing with other businesses operating in the urban area and willingness to share resources (Buldeo Rai et al., 2017). Among all the stakeholders of urban freight logistics, the LSPs face the biggest challenge of making customers (Rosano et al., 2022) and freight logistics policies enforced by public authorities.

In this study, factors comprising the ESUL state have been defined by reviewing current national freight policy guidelines. This has been contrasted with the findings from literature regarding the enablers and barriers to implementing ESUL practices and operational decisions adopted by LSPs that pose challenges to long term sustainability goals set by the national government. Through this paper, the research question that has been addressed is: **How consistent are LSP practices with National Freight policies?**

2. Literature Review

2.1.Freight Logistics in Urban Areas

Unsustainability in urban freight logistics has been highlighted in research over decades that concerns all stakeholders (Lindholm, 2013) making environmental sustainability an important agenda for the LSPs and governments including PPBs (Wehner et al., 2022). Freight logistics requires planning involving them at the right time to ensure efficiency and successful implementation of sustainable measures (Lindholm, 2013). To enable sustainable freight strategies, collaborative partnerships between stakeholders are required (Lebeau et al., 2018). However, they are faced with several challenges mainly due to their often conflicting objectives (Pan et al., 2021).

Freight logistics in an urban area is largely guided by transport policies developed at various stages of administration but implemented by local authorities (Malik et al., 2017). Taking a policy-based approach highlights problem areas for each stakeholder providing the PPBs with an opportunity to make informed reforms to existing policies (Macharis et al., 2014); provide better insights into existing policies that govern the freight landscape; hold each stakeholder responsible for its action and enforce the development of better transport policies in collaboration with each other (European Commission. Directorate General for Mobility and Transport., 2017).

2.2.Freight policy for urban freight logistics

Stakeholders of the urban freight ecosystem often have conflicting interests (Cleophas et al., 2019; Pan et al., 2021; Russo and Comi, 2011) that requires robust policies to manage them effectively. Thus, it is required to explore in-depth, the factors affecting stakeholders, particularly LSPs to adopt sustainable policy measures and the parameters that the PPBs consider for implementation. It is necessary to understand these perspectives to successfully identify the enablers and barriers to the implementation of sustainable urban freight logistics policies.

2.3. Defining ESUL factors

The ESUL factors can be defined as the common challenges for both LSPs and PPBs that arise from urban freight logistics operations. These include environmental impacts, infrastructural impacts, and policy-related impacts. Through the identification of the ESULs, this study will identify the areas of opportunities that need to be addressed either through changing operational procedures or through policy measures, or a combination of both. Eight such factors were identified from policy and academic literature; They are listed in Table 1:

	ESUL Factor	Article References
1.	Emissions	(Kumar, 2021; Pan et al., 2021)
2.	Congestion	(Akgün et al., 2019; Muñoz-Villamizar et al., 2020; Paddeu and Aditjandra, 2020)
3.	Low carbon operations	(Evangelista et al., 2017)
4.	Skilled workforce in the freight logistics sector	(Akgün et al., 2020; Evangelista et al., 2018)
5.	Awareness and knowledge of urban freight logistics	(Akgün et al., 2019; Knoppen et al., 2021; Lozzi et al., 2018)
6.	Supporting infrastructure	(Diana et al., 2020; Paddeu and Aditjandra, 2020)
7.	Network optimisation	(Akgün et al., 2020; Pan et al., 2021)
8.	Technology	(Evangelista et al., 2018; Mangina et al., 2020; Wehner et al., 2022)

Table 1: ESUL factors identified in the study.

Each of these factors has a major influence on sustainable urban freight logistics operations, however, it also affects the LSPs the most due to the nature of their operations (Rosano et al., 2022). These factors also form the core of most policy guidelines that govern the freight logistics landscape in the UK. While freight logistics was a part of policymaking for PPBs, separate policy documents focusing on challenges posed by freight logistics operations have only started recently. The earliest document was published in 2011 that discussed major trends for the freight and logistics sector of the future.

Through the literature review, the importance of stakeholder involvement in the policymaking process was also examined. Since freight logistics involves private stakeholders (LSPs) using public infrastructure, conflict can be reduced by involving stakeholders early on. It will help to forecast stakeholders' reaction to policy changes and being able to predict the outcome of an interaction process aimed at consensus building (Le Pira et al., 2017).

3. Methodology

3.1. Overarching themes grounding this study

Three overarching themes- Urbanisation, Environmental sustainability and Freight transport and logistics were identified from the preliminary literature search that establish the grounds for this study. The interplay between these themes was analysed through a stakeholder perspective, for enabling ESUL practices through policy adoption.

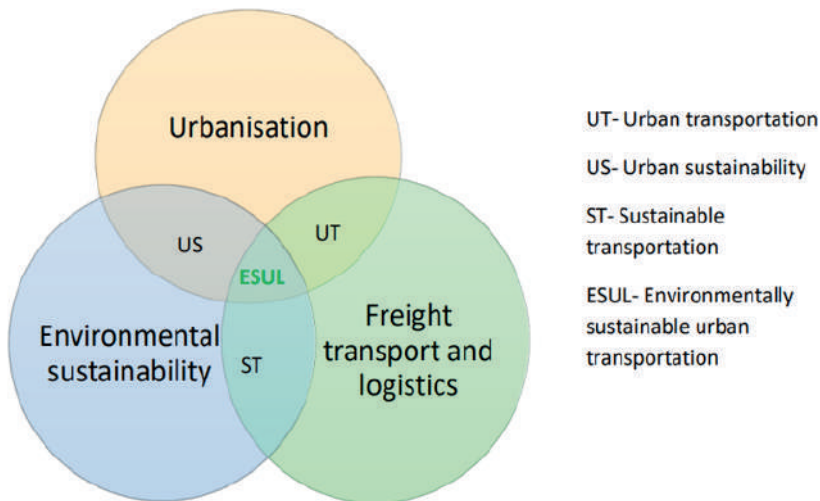


Figure 1: Over-arching themes and subthemes guiding this study

Figure 1 above explains the major themes and how their interactions can be used to map further subthemes that have guided this study. Keywords: “Freight logistics”, “Freight transport policy”, “Urban Freight Transportation”, “Freight Logistics” AND “Sustainability” and combinations of these strings were used to narrow down the literature search. Only peer reviewed papers, journal articles, reports and book chapters were considered for the literature study. Papers relating only to road freight transport, road freight policies, urban freight and sustainable freight transportation were considered. For policy related papers, only UK policy centric papers were considered. The scope of this study is limited to freight logistics practices adopted by LSPs, and policies influencing freight logistics by road.

3.2.Literature Review and analysis framework

This section discusses the literature extraction and analysis process.

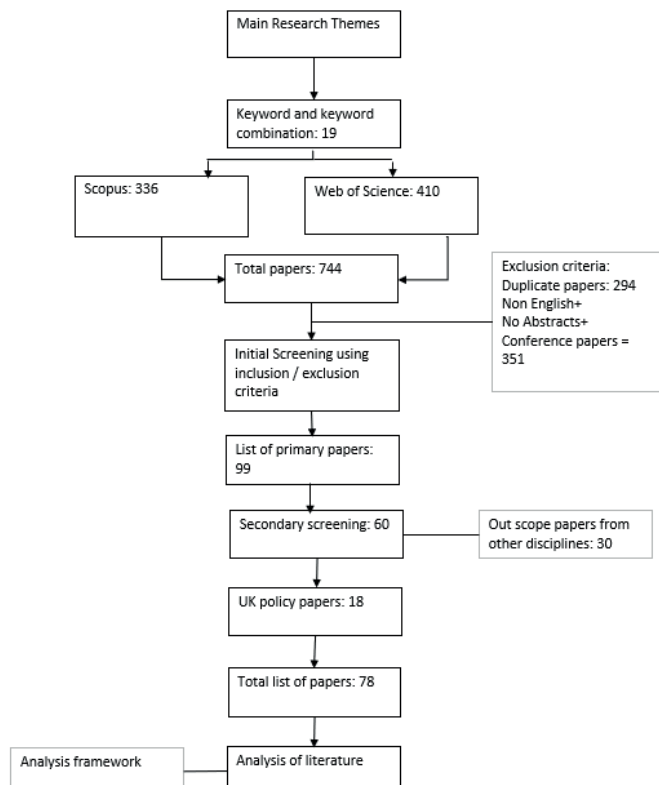


Figure 2: Literature Review framework

Figure 2 above provides the literature review framework used to extract and analyse the literature. The literature search showed that the study undertaken was multidisciplinary and complex in nature. A combination of policy research from national policy guidelines and academic literature on policy adoption were thoroughly reviewed to understand the current state of the freight landscape in the UK. Along with that, academic literature on logistics and transport research was reviewed in depth to identify the challenges presented by the freight and logistics sector and its impact on the environmental sustainability. Evaluation of both these streams of study presented some common premises that guided the formulation of the ESUL factors. Through the literature review, a set of practices that encompass ESUL state was established.

The literature review process followed the SLR guidelines developed by Durach et al (Durach et al., 2017). The current paper presents an interim outcome of an ongoing SLR. The research question addressed in this study arises directly from the review of the academic papers where stakeholder participation in policy adoption and implementation were analysed. This was followed by identifying ESUL factors that were then studied in detail to understand their impact on policy formulation, adoption and implementation. Freight policy literature was extracted from the UK government website under the topics Transport- Freight haulage and cargo. Consultation papers from both government agencies (Department of Transport) and private consulting firms (NIC, CILT) were considered. Reports and consultations focusing on freight logistics by roads were chosen for the study.

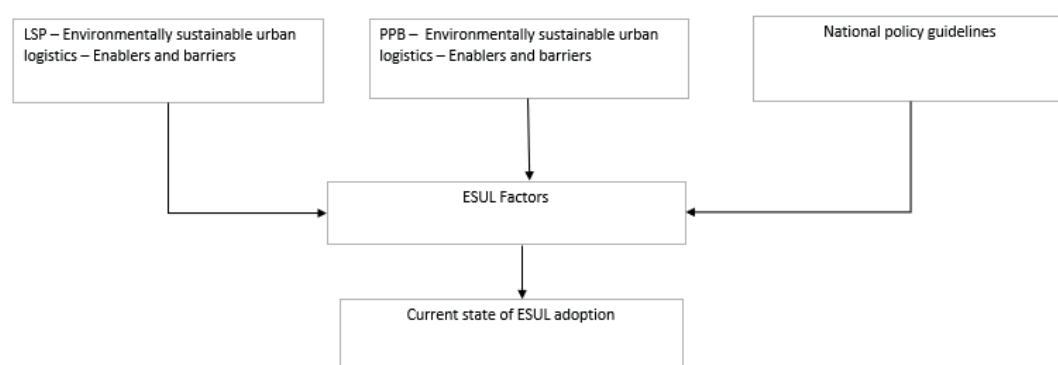


Figure 3: Analysis framework

Figure 3 above shows the analysis framework used to analyse the findings from the literature review. The enablers and barriers from the stakeholder perspectives were separately identified from the literature. The ESUL factors have been used to inform the analysis of the enablers and barriers from the stakeholder perspectives.

LSP – ESUL enablers	LSP – ESUL barriers
Internal organisation policies	High financial implications
Promoting green initiatives knowledge (Evangelista et al., 2017; Pan et al., 2021)	Lack of awareness of green initiatives by partners
Collaborative green initiatives with customers	Lack of human resources, skill and knowledge (Evangelista et al., 2018) (Transport, 2022)
Integrating environmental sustainability strategy in operations (Rosano et al., 2022)	
Support from regional and national government	Lack of financial support from customers and partners
Government policy regulations	Lack of well-defined frameworks
PPB – ESUL enablers	PPB – ESUL barriers
Stakeholder involvement (Transport, 2022)	Poor stakeholder involvement (Knoppen et al., 2021) (Transport, 2012) (Transport, 2022)
Low emission (CILT, 2011)	Inconsistent data sharing between private and public sector (Buldeo Rai et al., 2017)

Stakeholder focused policies (Knoppen et al., 2021)	Single stakeholder perspective
Collaborative actions from multiple stakeholders (Knoppen et al., 2021)	Lack of well-defined regulations for adoption of sustainable measures(Akgün et al., 2019; Stathopoulos et al., 2012)
	Contradictory laws and regulation on the adoption of environmental activities(Diana et al., 2020)
	Technical know-how and commercial solutions (Evangelista et al., 2018)
Tables 2 and 3 above lists the ESUL enablers and barriers from the LSP and PPB perspectives that affects policy adoption and implementation by these stakeholders.	

The study has been conducted in multiple stages. In the first stage, sustainable practices followed by LSPs have been identified and have been compared with policy guidelines. In the next stage, this has been used to inform the analysis of the enablers and barriers of reaching the ESUL state. This paper is at the first stage where the challenges faced by academic, practitioners and policy literature on urban freight logistics practices were systematically reviewed and its impact on reaching an environmentally sustainable state as defined by the UK climate goals for 2050 has been established. In the next section the findings and the results have been discussed in detail.

4. Results and Discussion

4.1.Enablers and barriers for LSPs

From the literature review, it is clear that most researchers examines urban transportation with respect to triple bottom line criteria that is economic, social and environmental performance (Kumar, 2021; Pan et al., 2021; Serrano-Hernandez et al., 2021). For LSPs, economic and social goals are easily achieved through their business models. By promoting knowledge of green initiatives within the organisation (Evangelista et al., 2017; Pan et al., 2021), they are able to promote a culture within the organisation (Evangelista et al., 2018). Explicit integration of environmental sustainability strategies in the organisation (Rosano et al., 2022) also helps to integrate regional and national sustainability targets. LSPs often use environmental sustainability to reduce operations cost and increasing company profitability (Evangelista et al., 2018) also improving customer relationships and overall supply chain effectiveness.

Implementation of sustainable practices also comes with its own set of challenges. For example, studies conducted by Evangelista et al (Evangelista et al., 2018) demonstrated several barriers ranging from organisational, financial or even technological for LSP organisations to execute environmentally sustainable practices. This study also highlighted that same parameter can be treated as either an enabler or a barrier by different stakeholders from their operational perspectives. LSPs are keen to include environmental sustainability by transforming negative externalities from their operations to an opportunity to promote sustainability practices and increase their competitive advantage. These practices are often guided by internal initiatives along with compliance with national and international environmental regulations. However, the challenges to adoption of these practices are often posed by their customers (Rosano et al., 2022). Studies have shown that LSPs do not always adopt all policy measures at all times in to optimise their operations based on their location (Buldeo Rai et al., 2019). Some of these decisions are also influenced by the customers these LSPs serve (Rosano et al., 2022). Lack of skilled resources in their workforce impact uptake of green initiatives and learning new technology that promote sustainable practices (Evangelista et al., 2018). There is often high financial impact when introducing new technology that can be a challenge without support from their customers (Akgün et al., 2020).

4.2.Enablers and barriers for PPBs

Researchers indicated several practices that policymakers at regional and national level promotes to encourage other stakeholders to adopt sustainable practices to achieve over all sustainability goals. These range from promoting the use of low emission vehicles for last-mile delivery (CILT, 2011), engaging stakeholders at early stages of policymaking to improve

transparency and partnership (Kumar, 2021), and encouraging collaborative action from multiple stakeholders (Knoppen et al., 2021). However, despite such initiatives from policymaking bodies and authorities, there are several challenges that have also been highlighted in these studies. Public policy-making bodies often treat freight and logistics as a whole sector to study the environmental impacts instead of treating the modes of freight transport separately (CILT, 2011). While this makes it easier to estimate the negative externalities as a whole sector, it fails to provide consolidated solutions to challenges faced by each transport mode.

For this study, only the policies related to freight transportation by road were chosen. For most of the policy documents, there was a focus on long term environmental sustainability of the sector as a whole (Transport, 2012). Urban freight logistics require the use of public infrastructure by a lot of private stakeholders. However, the stakeholder problems are not individually considered during policy formulation, resulting in generic solutions for the entire sector (Buldeo Rai et al., 2017; Lebeau et al., 2018). Generalised solutions for the freight and logistics sectors have historically not worked out because of the diverse objectives of stakeholders involved (Transport, 2020). The transferability of generic policies have also been argued based on demography of targeted urban area (Amaya et al., 2020; Knoppen et al., 2021). While stakeholder involvement at planning stages has been considered key to making informed decisions, there is little to no information on the level of involvement of stakeholders, the process of their involvement and how their issues are prioritized during the policymaking process. Stakeholder objectives for policy reforms have been identified since 2011 but no significant progress has been made to put them into action (Transport, 2022). It was also observed that the recent focus on all the policy guidelines focus on decarbonisation (Transport, 2020) (Transport, 2021). While carbon reduction contributes greatly to meet the UK 2050 climate goals, it fails to address other issues that affect current freight operations in congested urban areas.

5. Conclusion

In this study, the enablers and barriers to the adoption of ESUL have been identified. The ESUL factors are challenges that both these stakeholders are striving to address. This was an important exercise to understand what practices could help LSPs to achieve ESUL goals set by the policymakers. It could be clearly derived from the study that LSPs only adopted policy guidelines permitted within their operational costs. On the other hand, for PPBs, this could mean that reaching the collective sustainability goals would be increasingly difficult unless they are able to create effective collaboration plans with the LSPs.

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A PREDICTIVE ANALYTICS MODEL ON CIRCULARITY OF SMARTPHONES

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Introduction

Sustainability has become increasingly important within the business world in recent years. Although it may seem counterintuitive to emphasize sustainable business practices in order to increase profitability, the most profitable businesses are also the most sustainable. In recent years, environmental, social, and governance (ESG) metrics have been used to assess companies' ethical and sustainable practices (Chladek, 2019). As opposed to linear economics, which involves take-make-consume-throwaway, circular economy emphasizes on two complementary cycles. The biological cycle (materials decomposable by living organisms) and the technical cycle (materials that cannot) (Bourguignon, 2016).

With a yearly e-waste generation of 50 million metric tons, the average person produces seven kilograms of e-waste (Alves, 2022). Small IT and telecommunication equipment, such as smartphones, GPS devices, pocket calculators, routers, computers, printers, and telephones, contribute approximately 9% to global e-waste according to the Unitar Global e-waste Monitor 2020 report (Tiseo, 2020). The main purpose of this paper will be to compare the of sourcing relevant raw materials for smartphone production against materials that have been reclaimed from end-of-life smartphones. The paper further develops a predictive analytics model that is used to evaluate the relationship between smartphone sales across 2007 -2022 to recaptured and reclaimed material.

Literature Review

Circular Economy

Ellen Macarthur Foundation describes the circular economy as a systemic approach to economic development that benefits society, businesses, and the environment. As Ellen Macarthur Foundation explains, a circular economy eliminates waste and pollution, circulates products at maximum value, and regenerates nature. By transforming to renewable energy and materials, the circular economy minimises waste, benefiting businesses, the environment, and the environment's health (Ellen Macarthur Foundation, 2023a). After a product has passed its end-of-life date, the materials used in it should remain in the economy so that they can be reused and repurposed many times, creating additional value. A circular economy requires reusing, repairing, refurbishing, and recycling existing products and materials previously considered 'waste', now considered a valuable resource (Ellen Macarthur Foundation, 2023a).

E-waste

In accordance with the European Directive on WEEE, electronic waste is equipment that generates, transfers, or measures electrical currents or electromagnetic fields (Cui and Jørgen Roven, 2011). Temperature exchange equipment, screens and monitors, lamps, large equipment, small equipment, and small IT and telecommunication equipment are among the six categories (Unitar, 2020). Gartner simplifies the definition by describing electronic waste (e-waste), or e-waste, as a generic term used to describe any old, discarded or end-of-life electrical or electronic equipment (Gartner, 2023). In this paper, we will be looking specifically at smartphones due to the interval at which consumers upgrade their smartphones is 2-3 years which in turn leads to high amounts of e-waste (European Economic and Social Committee, 2019).

6 – R (Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture) model

With a closed-loop, multiple-product life cycle system as its foundation, the sustainable manufacturing approach utilizes the 6R R (Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture) methodology for products over multiple

lifecycles. By reducing resource usage during pre-manufacturing, reducing energy, materials, and other resources during manufacturing, and reducing emissions and waste during use, the 6R methodology aims to minimize resource consumption (Jawahir and Bradley, 2016). A product can be reused after its first life cycle, thereby reducing the use of virgin materials for newer products by reusing it or its components. Recycling involves converting waste into new materials while recovering involves collecting, disassembling, sorting, and cleaning products for reuse. With redesign, components, materials, and resources from previous product lifecycles are used to redesign next-generation products. Using remanufacture, used products are reprocessed to return them to their original state or to a like-new state without losing functionality (Jawahir and Bradley, 2016).

Using a closed-loop 6R-based lifecycle system for sustainable manufacturing, we could maintain a near-perpetual supply of raw materials, energy, and resources while reducing waste and emissions. In order to achieve economic and societal benefits with minimal adverse environmental impact, it is crucial to understand the 6R-based material flow and its impact on value creation (Jawahir and Bradley, 2016).

Accordingly, this paper develops an empirical study that focuses on e-waste generated from smartphones. The paper also analyses potential opportunities for improving circularity within that product's supply chain through the use of a predictive analytics model.

Research Methodology

The research design for this paper will employ a case study with the focal unit of analysis being the iPhone. Through the case study, the circularity of various material streams obtained from end-of-life iPhones will be examined. Using empirical analysis, the study will assess the iPhone's performance across the 6Rs by examining the various channels for managing smartphone returns and reclaiming valuable materials from them.

The data to be analysed are the sales and recycled smartphones from 2007-2022. ARIMA (Autoregressive Integrated Moving Average) will be used to analyse sales and recycled data of iPhones sold between 2007 and 2022. This will be run using R (variations of (1,0,1) and (1,1,1) were trialled however, this paper only includes the results with the least error). The same data sets will be compared with double and triple exponential smoothing that will be run on Excel to predict how much material can be extracted from end-of-life smartphones and reintroduced into the manufacturing process.

Limitations To the Study

This study poses a few limitations which are listed below.

- This study is purely based on secondary published data.
- This study only considers the iPhone due to the availability of published reports.
- The actual amount and value of various raw materials are based on previously published reports.

Apple iPhone as a Case Study

After the first iPhone was introduced 15 years ago, Apple has become the largest company in the world in terms of market capitalization (Vincent, 2022).

Over the years Apple first started with releasing one iPhone each year from the year 2007 to the year 2012 and then moved to two iPhones each year from 2013 to 2016. In 2016 Apple released their first budget phone iPhone SE in the month of March and its two flagship phones as usual in the month of September. This pattern of three phones a year went on till the year 2018 and in 2019 they launched four phones and this pattern went on till 2022 when they launched 5 phones (Vincent, 2022) (Keach, 2022). This showcases the shortening of consumers' average usage time for smartphones.

Apple in their 2023 environmental progress report stated that they have been using recycled materials in their iPhones since the year 2017 (Apple, 2023). Figure 2 displays the various recycled elements used over the years in their iPhones.

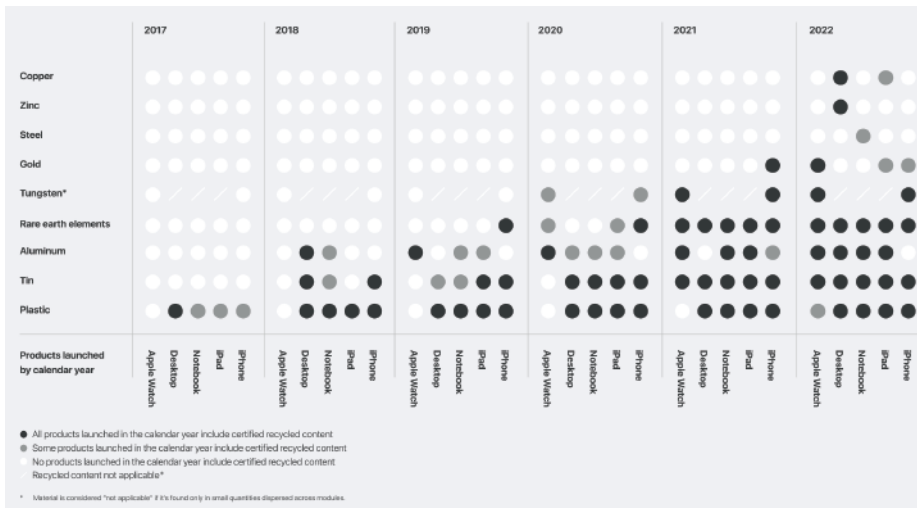


Figure 1: Transition to certified recycled materials by product line (Apple, 2023).

Considering these certified recycled materials used in iPhones namely Gold, Tungsten, Rare earth materials, Aluminium, Tin and Plastics, Apple by 2025, aims to ship 20 per cent of their products that are made from recycled or renewable materials. Apple has accelerated their efforts to use 100 per cent recycled copper, tin, gold, and rare earth elements in select components (Apple, 2023). Accordingly, the iPhone as a focal unit of analysis for this case study, can be used to offer an empirical analysis using ARIMA, Double exponential smoothing (DES) and Triple exponential smoothing (TES) to develop a predictive model on the circularity of the iPhone.

Data Analysis

Sales Analysis

From the year 2007 to 2022 Apple sold an average of 49.53 million iPhones (Laricchia, 2018) (Gartner, 2020) (Stamford, 2021a) (Stamford, 2021b) (Gartner, 2022) (Curry, 2023) from the sales shown in Figure 2, ARIMA is used to analyse the sales trend and forecast the sales for future years. It can be inferred that there is a maturity in the sales as seen in Figure 3, also there is a spike in sales usually at the end of the 3rd quarter year on year due to the launch of the new iPhones. The results from the ARIMA forecast (figure 4, top left corner) show a negative trend and this could be due to market saturation of the product as seen in Figure 4, increased life cycle of future iPhones and increased usage by the customer.

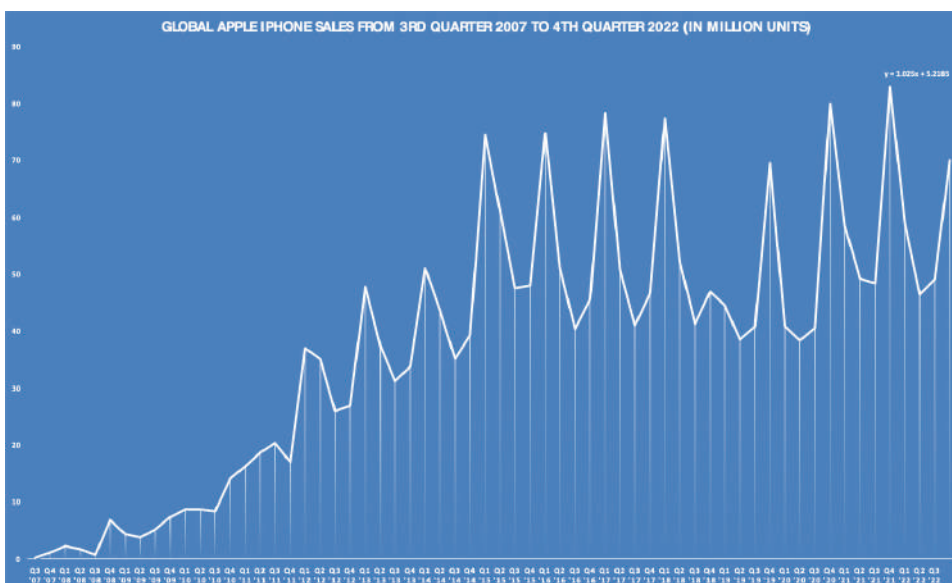


Figure 2: Global iPhone sales from 2007 to 2022 (Laricchia, 2018)

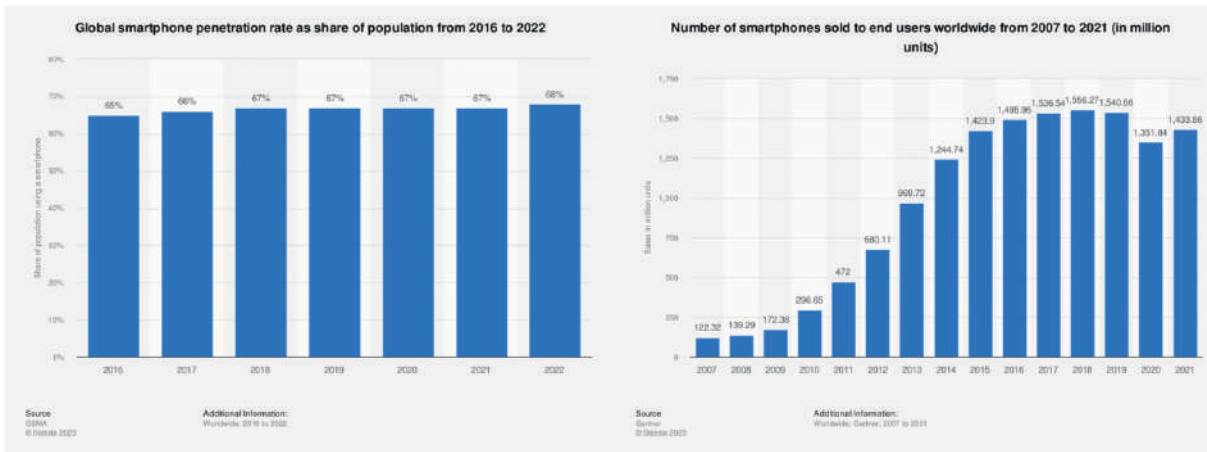


Figure 3: Global Smartphone Statistics (Laricchia, 2022) (Laricchia, 2023)

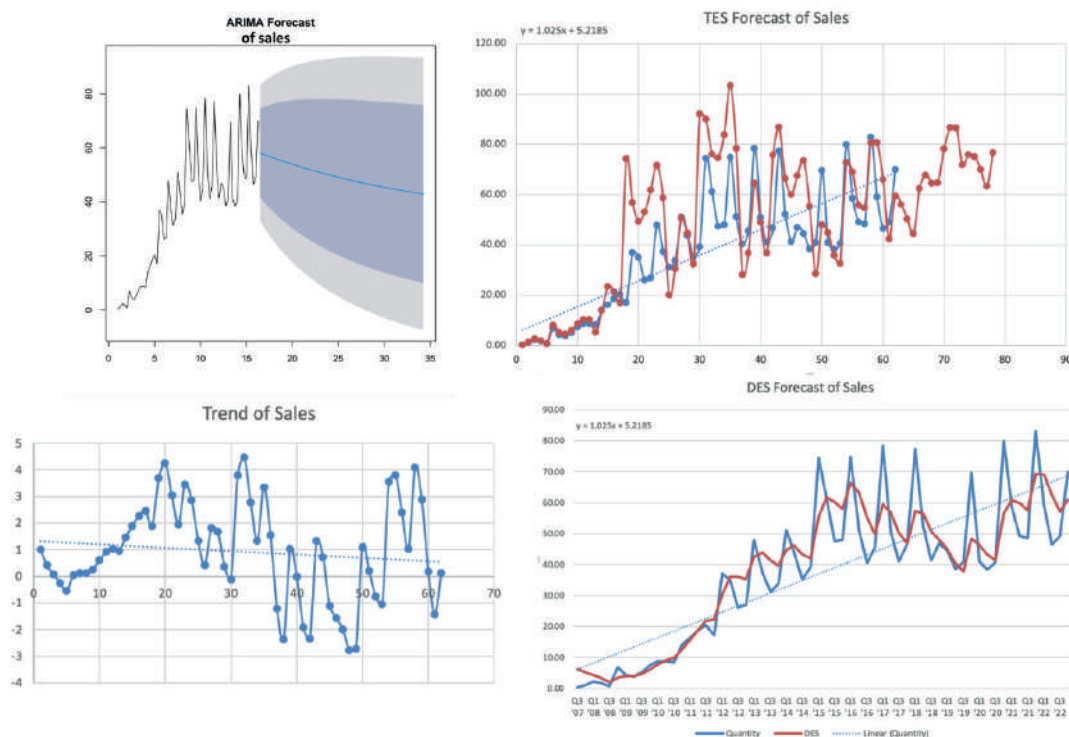


Figure 4: ARIMA, DES, TES Forecasts and DES Forecast Trend of iPhone Sales (Author, 2023)

Analysing the results from the Double exponential smoothing (DES) (figure 4 bottom right corner) and Triple exponential smoothing (TES) (figure 4 top right corner) we can notice similar patterns. But the DES and TES forecasts show a positive trend. When the forecasts are compared DES shows the lowest error percentage of a mean absolute error (MAE) of 6.38 whereas ARIMA shows an MAE of 8.88 and TES an MAE of 12.29. On the contrary, when the trend of the DES forecast (figure 4, bottom left corner) which shows the lowest error is analysed, the trend shows a negative trend which is consistent with the ARIMA forecast.

The 6 Rs (Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture) Analysis of Apple

Reduce

Apple in their Environmental impact report mentions that they are in pursuit of reducing their use of freshly mined materials and are in pursuit of increasing their use of recycled materials in their phones (Apple, 2023). From the iPhone 12 apple has also stopped shipping the charger brick with a new iPhone in the box (Gaines, 2022). Additionally, Apple's new boxes

do not include earphones, or EarPods, which reduces packing waste as well as e-waste by avoiding shipping a phone together with accessories such as chargers and earphones (Porter, 2020). Consequently, each iPhone sold by the company consumes less raw materials. This change is also expected to reduce carbon emissions by 70 per cent by creating a smaller retail box, which will allow 70 per cent more units to fit on one shipping pallet (Porter, 2020)

Reuse

Apple like many other smartphone manufacturers sell refurbished iPhones on various platforms such as Amazon, Argos, and Network contractors such as EE, GiffGaff, O2 etc. Apple intends to ship 20 per cent of its products made of recycled or renewable materials by 2025, considering the certified recycled materials used in iPhones, such as gold, tungsten, rare earth elements, aluminium, tin, and plastic. In select components (Apple, 2023), Apple has accelerated their efforts to use 100 per cent recycled copper, tin, gold, and rare earth elements. As part of Apple's commitment to sourcing responsibly, Apple sources recycled, renewable, and primary materials for its products, packaging, and services to reduce its environmental impact (Apple, 2023).

Recycling

In order to sustainably collect end-of-life devices and develop recycling innovations, Apple strives to utilize old devices as raw material sources in the future (Apple, 2023). To maximize environmental, social, and supply chain impact, Apple prioritizes 14 materials for recycling and renewable efforts. In this process, many low-mass, high-impact materials have been prioritized. Metals we prioritize include aluminium, cobalt, copper, glass, gold, lithium, paper, plastics, rare earth elements, steel, tantalum, tin, tungsten, and zinc (Apple, 2023).

The WEEE set targets for the recycling rate was set to a maximum of 65% in 2019. In their report, the European Economic and Social Committee, (2019) uses three recycling bands as shown in Table 1. A forecast has been done with these three limits. From the ARIMA forecast, we can notice a negative trend with recycling as well, this can be due to a drop in sales of smartphones over the years and the customers moving to other new products, longevity of the smartphone life cycle and increase in software support for hardware. When the ARIMA results shown in figure 6 are compared with the Results obtained from DES in figure 7 and TES in figure 8, we can notice that both forecasting techniques show an increasing trend when the sales are analysed over time. On the contrary, when the trend of the DES trend in figure 9 is analysed, it shows a declining trend. This supports the results shown by the ARIMA forecast.

Variables	Baseline	Lower bound	Upper bound
Recycling rate	12%	35%	65%
Average lifetime	21.6 months	33.6 months	45.6 months

Table 1: Recycling Rates and Average lifetime (European Economic and Social Committee, 2019)

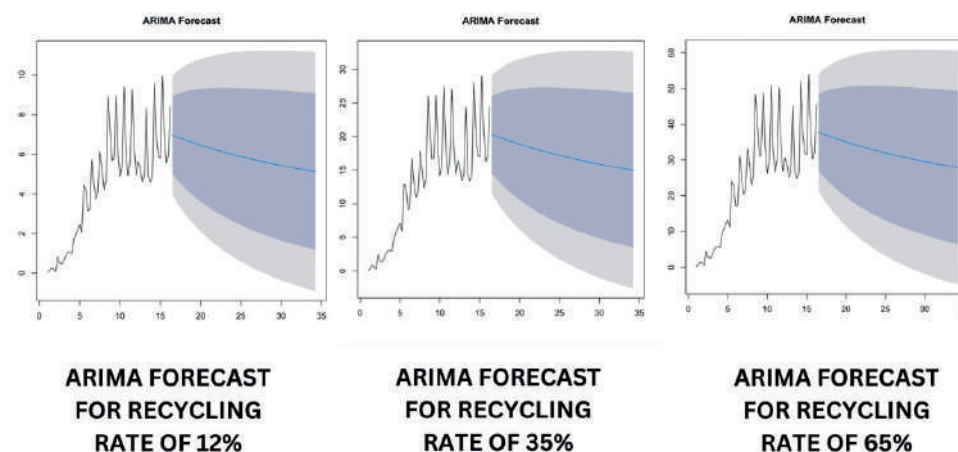


Figure 6: Arima Forecast for 12%, 35%, and 65% Recycling Rates (Author, 2023)

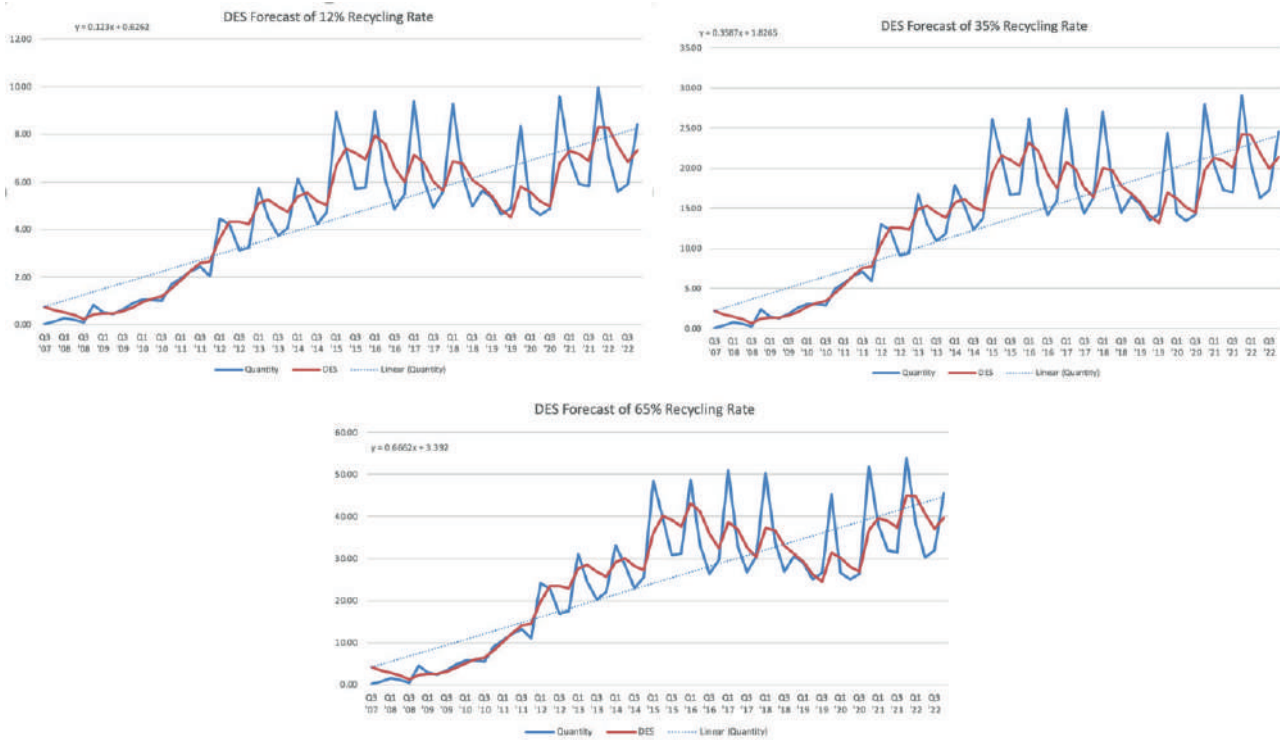


Figure 7: DES Forecast for 12%, 35%, and 65% Recycling Rates (Author, 2023)

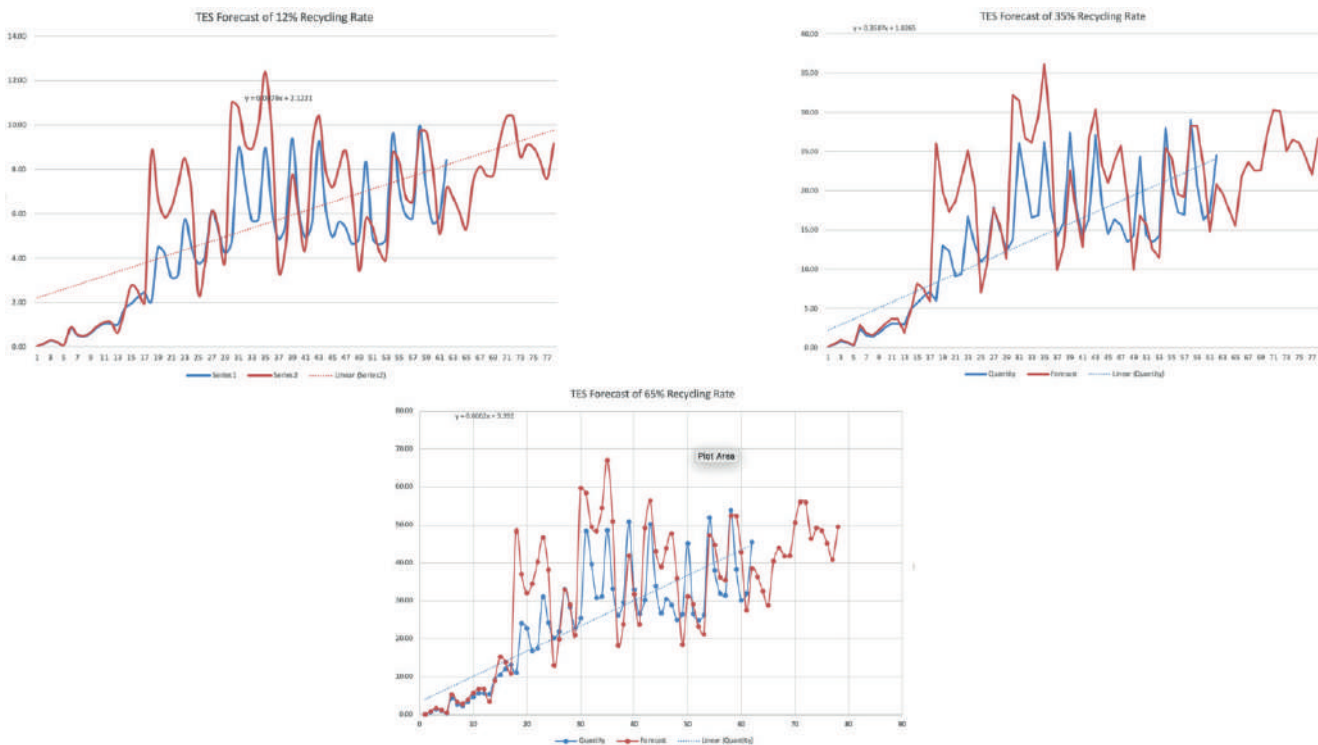


Figure 8: TES Forecast for 12%, 35%, and 65% Recycling Rates (Author, 2023)

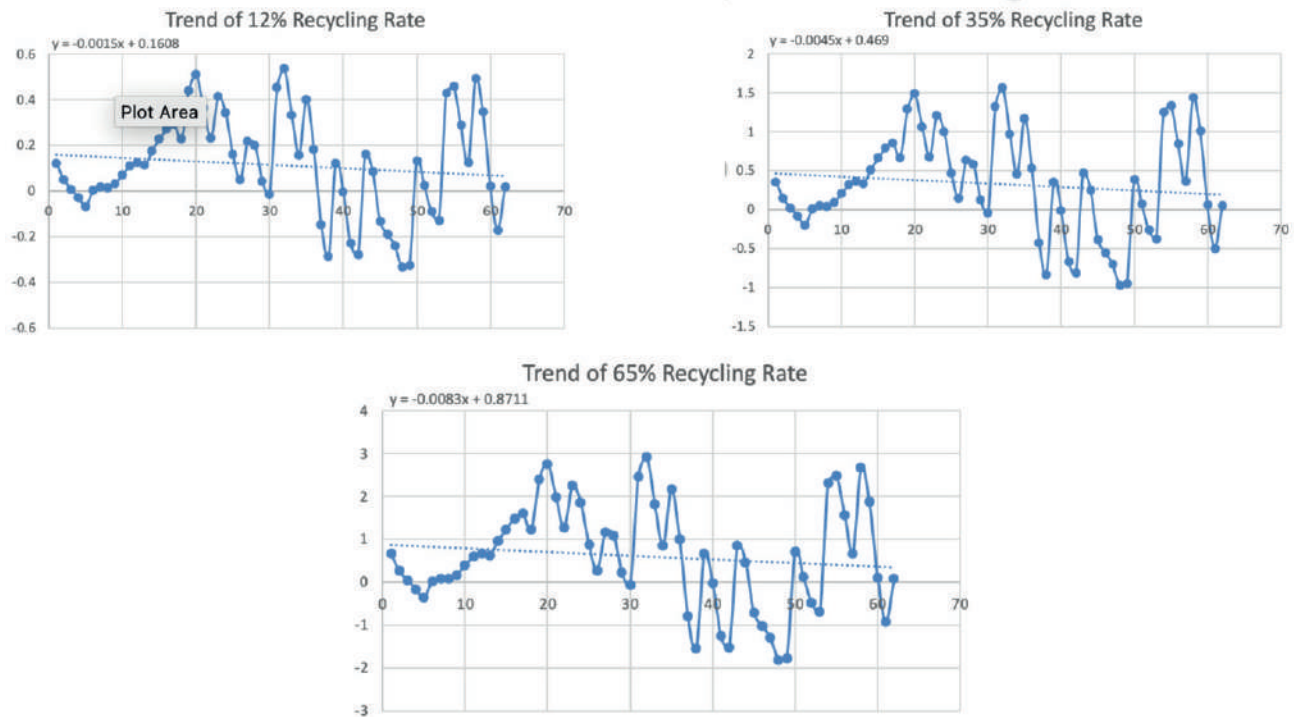


Figure 9: Trend of DES Forecast for 12%, 35%, and 65% Recycling Rates (Author, 2023)

Table 2: List of Critical Metals and Prices

Material	Approximate Usage in grams	Price/g in USD	Source
Aluminium	31.89	0.0022725	(Trading Economic, 2019)
Gold	0.03	62.86	(BullionVault, 2023)
Silver	0.21	0.8	(BullionVault, 2023)
Copper	14.26	0.008624932	(Trading Economic, 2019)
Cobalt	8.35	0.03342	(Trading Economic, 2019)
Lithium	0.93	0.3075	(Trading Economic, 2019)
Palladium	0.01	44.86992716	(Trading Economic, 2019)
Tin	0.01	0.028809	(Trading Economic, 2019)
Tungsten	0.3	0.04557	(Metal.com, 2023)
Total	55.99	108.9561236	
Total Price	6100.45336		

In the DES forecast, considering 65% of smartphones are recycled, an average of around 33 million smartphones are estimated to have been recycled between 2007 to 2022 and the total amount of raw materials salvaged from the iPhone, according to the composition list by the European Economic and Social Committee (2019), can be approximated to around 55.9 grams based on Apple's list of materials at a total cost of 6100 USD per phone as shown in table 2.

Recover

To recover materials from iPhones Apple, have their trade-in policies. Customers can access the value of their current device by using Apple Trade-In or a third-party program. Through longer-lasting devices, Apple's customers can access the value of their current devices. Using the value of a trade-in device as a credit, customers may upgrade to the latest products. In addition, refurbished products keep products useful for a longer period of time, allowing new customers to experience Apple's products and services for the first time. As Apple offers more products and services to a greater number of people, and as those products last longer, they are better for the environment (Apple, 2023).

Redesign

In designing its products, Apple ensures minimal interruptions from maintenance and repair during continuous use. Engineers at the company's Reliability Testing Lab evaluate the performance of materials, components, and fully assembled products against strict durability standards. The durability standards are developed by in-depth user studies, and product development involves testing numerous units of a product (Apple, 2023). Designing long-lasting products is an integral part of Apple's philosophy of maximizing the use of materials. Their activities include developing durable hardware, leveraging software updates to extend functionality, providing convenient access to high-quality repair services, and directing devices and parts to be refurbished and reused (Apple, 2023).

Remanufacture

It is Apple's objective to provide customers with more repair options and to design more durable products. The iPhone 14 and iPhone 14 Plus feature updated internal designs that enhance the accessibility of internal components and the repairability of the back glass. Additionally, the iPhone is equipped with even more repairable modules as well as enhanced durability and water resistance features. In the iPhone 14 and iPhone 14 Plus, an updated internal design was introduced, improving the accessibility of internal components and the repairability of the back glass. This allows for easier fixes. With the new internal design, the aluminium housing and back glass are no longer integrated, so the housing does not need to be replaced in order to repair the back glass (Apple, 2023).

When products are refurbished and reused, their environmental impact is reduced, including their carbon intensity over their lifecycle. By designing its products to serve multiple owners, Apple extends the life of its products, allowing its customers to exchange their devices for upgrades as they need them. As part of Apple Trade In's end-of-life options, customers can access the value of their current device or trade it in for free (Apple, 2023).

The number of parts that can be recovered and refurbished to high quality and performance standards is increasing, and Apple is increasing the number of parts that can be recovered and refurbished for use. As devices are repaired, fewer spare parts will be required. Additionally, Apple focuses on reusing accessories sent for recycling, such as sending collected power cables and adapters to final assembly sites, where they serve as power sources for final assembly products (Apple, 2023).

Conclusion

In this paper, the predictive analytics run evaluating the sales and recycled data sets shows that there is a negative trend in sales as well as in recycling. This negative trend could be attributed to a number of reasons:-

- Smartphones sold each year have reached more than 1000 million units with the smartphone market reaching maturity.
- The smartphones manufactured are built to last, increasing product longevity.
- Hardware and software integration by smartphone companies providing software support for longer periods of time could make smartphone users hold on to their phones for a longer usage period.
- Consumers could also have access to smartphone upgrades from network carriers such as EE, O2, GiffGaff, etc, on contracts, that allow them to switch to newer models of smartphones when required.

Additionally, Smartphone manufacturers can take various steps to improve sustainable manufacturing mainly by prioritising using recycled materials, salvaging their e-waste for critical raw materials and increasing their research and development to increase their product longevity to make sure that the product stays in use for a longer period of time.

Even though the data shows an overall negative trend from 2007 to 2022 the data also shows that there has been a significant portion of smartphones have been sold and the predictions from ARIMA, DES and TES provide evidence that this will continue to be in the millions of units at least for the next 10 years.

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FACILITATING DIGITAL PRODUCT PASSPORT WITH BLOCKCHAIN IN CONSTRUCTION SUPPLY CHAINS

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Abstract: The Digital Product Passport (DPP) is a circular building policy concept promoted by the EU and the UK. However, simply complying with the DPP in the digital world may not effectively improve product circularity in the physical world. To bridge this gap, we present a two-period Stackelberg game model of closed-loop supply chains (CLSC) to investigate the impact of reverse channel selection on CLSC performance and propose strategies for improvement. To enhance overall performance, we recommend the adoption of a large trading platform as the most effective model, the implementation of a minimal circularity policy on manufacturers, and the utilization of two-part tariff contracts within the CLSC. However, successful implementation of these strategies necessitates reliable information sharing among multiple parties in the construction supply chain. To address this requirement, we propose a blockchain-based solution that guarantees data integrity, thus facilitating the establishment of a large collecting and exchange platform. Furthermore, we propose that circularity inspections on new products can incentivize manufacturers to improve circularity. The policy benefits resulting from our recommendations include enhanced product reuse capability and collection rate, reduced wholesale prices, and increased acceptance of DPP. This study provides practical guidance for companies and governments when making retrofit decisions in the context of the DPP.

Keywords: Circular supply chain, Digital product passport, Two-part tariff contract, Blockchain

Introduction

The Digital Product Passport (DPP), a concept of circular building policy, is approved by the European Union (EU) and the United Kingdom (UK) to promote sustainability and transparency in the use of building materials and products (King et al. 2023). Other similar concepts include the Cradle-to-Cradle Passport (Maersk2018), Materials Passport (BAMB2023), and Asset Administration Shell (Adisorn et al.2021). Essentially, these concepts are digital documents that provide a comprehensive record of a product's entire life cycle, including its design, materials, manufacturing processes, and environmental impact (Watson et al.2023). The implementation of the DPP is a crucial step in advancing a circular economy and promoting sustainable construction practices. A visual representation of this process is illustrated in Figure 1(a). Figure 1(b) provides an example of a DPP record adopted by Circularise, a leading software platform that provides Digital Product Passports for industrial supply chains. The data contain both static (e.g., recycled content) and dynamic (e.g., activity) information.



Figure 1 Digital Product Passport and an Example in the Built Environment

At present, it is unclear how granular DPPs should be (Gotz et al.2022) because the structure of a DPP can vary depending on the industry, type of product, and intended use. However, EU regulations outline certain key elements, such as product identifier, GTIN, commodity codes, regulatory compliance, substances of concern, user manuals, safety, and manufacturing information, as listed in Table 1. Beyond the regulation, value chain partners can include additional information in the DPP. The overarching purpose of a DPP is to provide a consistent, readily accessible repository of a product's specifications, attributes, and other pertinent information, with the ultimate aim of promoting transparency and accountability throughout the product life cycle.

By connecting BIM files, the integration of digital product passports forms the comprehensive logbook of the entire building (Construction Products Europe 2023a), enabling and promoting the second life-cycle of products while generating economic, environmental, and social benefits. Especially, DPP increases the reuse potential of the product. Nonetheless, economic actors within the built environment, particularly manufacturers, encounter additional expenses associated with product information upkeep and product quality enhancement (King et al. 2023). Therefore, the industry is exploring ways to enhance the economic performance of DPP. This paper aims to fill this research gap by addressing three questions:

- How does reverse channel selection impact the decisions and benefits within the supply chain in the context of DPP?
- What measures can be taken to enhance the performance of the closed-loop supply chain?
- What policy designs can effectively incentivize the adoption and implementation of DPP?

To address these research questions, we develop a two-period Stackelberg game model to analyze decision-making and rewards in the supply chain. In this model, the manufacturer act as the Stackelberg leader, while the contractor and collector act as followers. In the first period, the manufacturer determines the product's reuse potential and wholesale price, while the contractor sets the retail price. In the second period, the collector decides the collection rate. Additionally, we consider the discount factor between the two periods, representing the beginning and end of the product's first life cycle. Expanding upon the game model, we propose implementing a large recycling and exchange platform as the most efficient collection model. We also suggest enhancing the performance of the closed-loop supply chain (CLSC) through the use of two-part tariff contracts. Moreover, we propose incentivizing the adoption of DPP through a well-designed minimal reuse potential policy. Finally, we introduce a Blockchain-based solution supporting DPP specifically tailored to the construction industry.

This study makes two significant contributions, both in literature and practical application. Firstly, it is worth noting that this paper is the first of its kind to present structural findings about the decision-making process of manufacturers when incorporating circularity principles into the production of durable products, particularly within the framework of a product digital passport. Our research sheds light on the economic implications of traceability in the built environment, specifically from the perspective of CLSC. Secondly, our findings offer valuable theoretical evidence and management insights for manufacturers, aiding them in selecting appropriate reverse channels and determining the optimal investment level in DPP. Additionally, our research guides government entities in designing effective incentive policies to promote the adoption of DPP.

The remainder of this paper is organized as follows. Section 2 provides a review of the relevant literature. Section 3 presents the models. The analysis process is ignored due to space limitations. Section 4 lists main findings and provides direction for future research.

2 Literature Review

Three streams of literature are primarily relevant to our study: DPP in the built environment, take-back management in the closed-loop supply chain, and impact of traceability in the supply chain.

2.1 Digital product passport in the built environment

A few studies have been conducted on DPP, focusing on its definition, goals, potential benefits, and implementation challenges. For example, King et al. (2023) conducted a scoping review that covered DPP's definition, purpose, and viewpoint. The review highlighted some implementation challenges, such as the complexity of supply chains, and recommended future research directions. Another study by Koppelaar et al.(2023) presented a conceptual design for a circular supply management

system for critical raw materials based on DPP. The design contributes to enabling the implementation of DPP and improving the recycling of critical raw materials. Blockchain technology has emerged as a promising solution to implement DPP in the construction industry. Several studies have explored the potential of blockchain-based applications for this purpose. Xu et al. (2023) reviewed existing blockchain consensus protocols applied in the construction industry. They also evaluated the suitability of different consensus protocols for these applications. Shojaei et al. (2021) proposed using blockchain technology to enable a circular economy in the built environment sector. They discussed the benefits of using blockchain, including transparency, accountability, and enhanced resource efficiency, and highlighted the potential for reducing waste and improving resource management. Finally, Wu et al. (2023) proposed a blockchain non-fungible token-enabled product passport for construction waste material cross-jurisdictional trading. The passport provides information on waste materials' origin, composition, and quality, facilitating cross-border transactions and reducing waste disposal.

The literature underscores the potential of DPP and blockchain technology to promote sustainability and a circular economy. Nevertheless, implementing these technologies presents several challenges that need to be addressed, particularly regarding stakeholder cooperation. This paper aims to tackle this challenge and provide practical information about its implementation.

2.2 Take-back management in closed-loop supply chain

The concept of CLSC has garnered significant attention in the past two decades due to its potential to reduce environmental impact while improving economic benefits. Recent systematic literature reviews by Sudusinghe and Seuring (2022), Gebhardt et al. (2022), and Aldrighetti et al. (2023) highlight the progress made in this field. Our paper is highly correlated with take-back management in CLSC. Classic research by Savaskan et al. (2004) established various collection models for CLSC. Building on their work, numerous studies have optimized reverse channel selection decisions in CLSCs. Chu et al. (2018) found that the joint third-party collection model serving multiple manufacturers may outperform the model managed by retailers and manufacturers, contrary to existing findings considering a single manufacturer. Tian et al. (2019) compared the recycling strategies of manufacturers in the context of co-opetition, finding that producers may recycle their products without cooperating with others in markets with intense competition and differentiated market sizes. Several studies have evaluated policy implications for CLSCs. Alev et al. (2021) investigated the effectiveness of different Extended Producer Responsibility (EPR) implementation models for pharmaceuticals. Luo et al. (2022) investigated the impact of carbon tax policies on manufacturing and remanufacturing decisions. Huang et al. (2019) investigated the design of EPR-based take-back legislation when considering the trade-off between the durability of the product and the recyclability. Numerous studies have followed emerging technology and business models. Cao and Choi (2022) compared full-trade-in-return and partial-trade-in-return policies in trade-in programs. Dhanorkar (2019) conducted an empirical study on the environmental benefits of internet-enabled consumer-to-consumer CLSCs.

The above works have optimized supply chain decisions, evaluated policy implications, and implemented innovative technologies. This paper investigates CLSCs in the built environment with digital product passports.

2.3 Impact of traceability in supply chain

The advancement of information technologies, especially blockchain, has made traceability systems more accessible and affordable for various industries. Hastig and Sodhi (2020) have identified critical factors for the implementation of blockchain in supply chain traceability. Numerous studies have investigated the value of traceability in the supply chain. Wang et al. (2019) explored the perceived benefits, potential deployment areas, and blockchain's perceived challenges in supply chains. Cui et al. (2023) proposed using traceability-driven blockchains to improve supply chain sustainability by improving transparency, accountability, and environmental responsibility. Traceability can also play a significant role in supply chain risk management. Chu et al. (2022) proposed a blockchain-enabled system to build trust in online trade-in programs and reduce the risk of fraud and misrepresentation. Traceability can change operations decisions in the supply chain. Iyengar et al. (2022) constructed an economic framework to understand the incentives of permissioned blockchain adoption in supply chains, finding that consumer welfare is enhanced, but manufacturers bear costs. Shen et al. (2022) investigated the use of permissioned blockchain technology to combat copycats in the supply chain and promote sustainability by preventing the production and sale of counterfeit products. Dong et al. (2023a) investigated how the adoption of traceability technology affects the incentives of supply chain members and identified risk mitigation schemes that support the use of blockchain. Dong et al. (2023b) also explored the impact of traceability on financial decisions in a multi-tier supply chain. They found that the benefits of traceability depend on the financing schemes in use.

These studies suggest that traceability significantly impacts the supply chain in terms of value creation, risk management, and operation decisions. This paper sheds light on the economic implications of traceability in the built environment, enabled by the recent advancement in digital product passports.

3 Model Setup

Taking cues from real-world examples in the built environment, including RIBA, Tata Steel, and Allies & Morrison, this paper presents a two-stage CLSC model.

In the first stage, the manufacturer produces new products using virgin materials. Without loss of generality, we assume the production cost per unit is zero. Instead, the manufacturer needs to determine the product's reuse potential $\theta \in [\Theta, 1]$, and incurs a total quality cost $C_1 \theta^\gamma$ of producing and digitizing products. Reuse potential is a technical terminology in the built environment (Interreg 2020). Here, θ represents the probability that a collected item enters the second life cycle, while $\Theta \in [0, 1]$ represents the minimum reuse potential mandated by government regulations. This related regulation has been proposed to regulate sustainable product ecodesign (European Commission 2022). Most of this paper focuses on the case where $\Theta = 0$, and the general case with $\Theta > 0$ is also discussed. The assumption of power function $C_1 \theta^\gamma$, where $C_1 > 0$ denotes a scaling parameter, is consistent with the literature on quality management (Baiman et al. 2001, Krishnan and Zhu 2006, Plambeck and Taylor 2016, Huang et al. 2019, Cui et al. 2023). Although some literature adopts a special quadratic cost function with $\gamma = 2$ to obtain closed-form solutions, we consider a general constant $\gamma > 1$. It is important to note that the cost function is convexly increasing in θ and twice continuously differentiable on the interval $[0, 1]$. The recyclable products produced are wholesaled to contractors at the unit wholesale price w . These contractors incorporate the products into buildings and charge users a unit price p . The quantity of products sold depends on the retail price set by the contractor-user relationship, defined as $q(p) = \phi - \beta p$, where ϕ represents the size of the potential market at this stage, and β is the price elasticity coefficient.

In the second stage of the process, a percentage τ of new products sold in the first stage is collected as used items for further processing. Among the collected items, a percentage θ decided by the manufacturer in the production stage undergoes reused. The collection process involves acquiring each unit of the used item at a cost denoted as A and subsequently transferring them to the manufacturer at a price of b . The quantity of items that undergo reuse is given by $\theta \tau q$. A reused product is identical to a new product but incurs savings in production costs of Δ . The collector needs to determine the collection rate $\tau \in [0, 1]$. Consistent with extensive literature on CLSC (Savaskan et al. 2004, Savaskan and Van Wassenhove 2006, Atasu et al. 2013, Luo et al. 2022), this study assumes that the acquisition cost for taking back products at the end of their first life cycle follows a quadratic function $C_2 \tau^2$, where $C_2 > 0$ denotes a scaling parameter. To ensure an interior point solution where $\tau < 1$, we also assume that C_2 is sufficiently large. More specifically, we require that $4C_2 > [\phi + \beta(\Delta - A)](\Delta - A)$, indicating that it is not economically viable to collect all used items. Since construction products often have a very long lifespan within buildings, the future price of used materials cannot be determined accurately until much later. Therefore, we introduce a discount factor δ that is assumed by all firms.

In the following, the superscript $i \in \{C, F, M, P\}$ refers to different CLSC models: centralized CLSC, decentralized CLSCs with facility operator, manufacturer, and large-scale platform-managed collection. Figure 2(a) illustrates model C, which serves as the benchmark. In this model, the manufacturer (M), contractor (C), and facility operator (F) form a coordinated system to serve the building users (U). Figure 2(b) depicts model F, where the facility operator acts as the collector of used items. This approach is easily implementable in practice, as the facility operator is physically close to the building and its users. Figure 2(c) presents model M, wherein the manufacturer collects used items directly from the users through its reverse channel. Figure 2(d) shows model P, which is a variant of model F with a variable scale n . When $n = 1$, P turns into F. However, when n is large, the collector (P) is either a company operating a lot of housing properties (e.g., Greystar), a network connecting many real estate companies (e.g., FIBREE), or a platform exchanging reclaimed construction materials (e.g., restado.de).

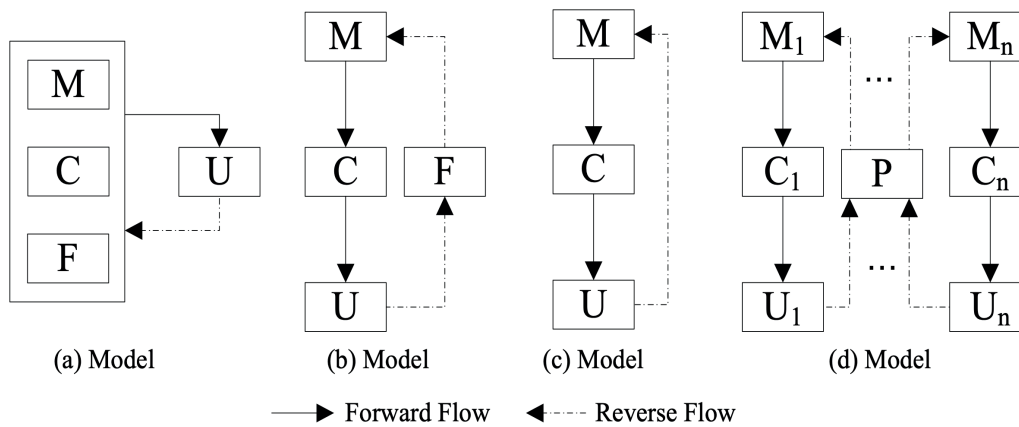


Figure 2 Collection models

4. Conclusion

By digitizing product information to support the transformation of the construction industry towards increased circularity, the DPP holds the potential to incentivize producers to adopt more sustainable practices. In this study, we investigated the influence of reverse channel selection on the decision-making process of supply chain members and examined how the anticipated benefits of DPP can be effectively realized within the context of DPP mandates. To accomplish this, we developed three CLSC models, each involving a single manufacturer, contractor, and collector. Through these models, we characterized and compared the equilibrium reuse potentials, collection rates, and sales quantities associated with different collection approaches. Additionally, we explored various strategies aimed at facilitating the implementation of DPP in construction supply chains. The findings of our analysis yielded several valuable insights.

Firstly, we found that a large exchange platform for used materials is the most effective model for implementing the DPP, as it incentivizes manufacturers to improve the circularity of their products and enhances economic benefits for all members of the supply chain. In the absence of such a platform, the manufacturer would be better equipped to handle the collection than the facility operator if they bear the same collecting cost.

Secondly, we propose the use of two-part tariff contracts to improve collection models in a manufacturer-dominant market. The manufacturer can effectively coordinate the CLSC through the implementation of separate two-part tariff contracts with fixed entry and per-unit fees for the contractor and the facility operator. For a large platform-managed collection, a recycling funding policy based on the collection rate, coupled with a two-part tariff contract, would be effective.

Lastly, we discuss two measures that can facilitate the adoption of DPP: the minimal reuse potential policy, circularity inspection, and blockchain-based digital solutions. A well-designed circularity target promotes collaboration among supply chain members and encourages the adoption of design for DPP. A circularity inspection at the beginning of a product's first life cycle can increase the discount factor, thereby motivating manufacturers to improve the circularity of their products. Our blockchain system ensures the integrity of DPP data, which is updated by all parties in the lengthy construction supply chain. This digital system enables the implementation of incentive mechanisms and has the potential to establish a large collecting and exchange platform.

However, this study has several limitations that should be addressed in future research. Firstly, our model assumes that all products are newly produced at the beginning of the first period. In reality, manufacturers often need to consider both new products and used products from existing buildings when making circularity decisions within the DPP framework. Integrating the decision-making process for new and used products would provide a more comprehensive analysis of reuse potentials and collection strategies. Secondly, our analysis considers a monopoly market where a single manufacturer dominates the market. Extending the analysis to include multiple competing manufacturers would be an interesting avenue for future research. By incorporating competition among manufacturers, we can explore how it impacts the optimal decisions regarding circularity and collection strategies. This would provide insights into the dynamics of a competitive market within the context of DPP implementation. Lastly, the absence of a large collecting and exchange platform supporting the digital product passport for circular construction materials in practice is acknowledged. It would be interesting to investigate potential strategies and mechanisms to facilitate the implementation of such a platform.

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TRANSITION CODESIGN FOR PURPOSEIVE ROAD FREIGHT DECARBONISATION

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Introduction

Trucks and vans represent c. 8.5% of United Kingdom (UK) carbon emissions (BEIS, 2021; DfT, 2017). Road freight is responsible for approximately two-thirds of these emissions and is considered to be a hard-to-abate sector. However, it must be abated to achieve net zero carbon by 2050 or sooner. Road freight decarbonisation progress to-date in the UK and other countries is nevertheless limited, despite a range of potential decarbonisation solutions.

Churchman et al. (2023) conduct a systematic literature review in which they identify 20 papers from a long list of 3,280 socio-technical and political transition studies that provide helpful insights for purposive road freight decarbonisation. Based on this, three preconditions for rapid and radical road freight decarbonisation are proposed: 1) techno-economically feasible options able to deliver this outcome; 2) a shared understanding of design choices that need to be codesigned; and 3) a politically and socio-technically feasible codesign framework for making design choices. The objective of this study is to test these preconditions with industry participants, policymakers and road freight experts. The specific case of food deliveries to supermarkets and supermarket distribution centres (DCs) in Great Britain (GB) was selected because of its large freight volume and relatively small number of easily identifiable freight customers and operators, which increases both the ability access research participants and the feasibility of a codesign approach.

In testing the 3 preconditions in relation to this road freight segment, the study contributes to the currently sparse literature that combines techno-economic, socio-technical and political perspectives for the purposive codesign of sustainability transitions. Specifically regarding road freight decarbonisation, the study addresses the research gap identified by Churchman and Longhurst (2022) that the vast majority of research is techno-economic, despite socio-technical and political factors also being important to this transition.

Methods

Data gathering

Due to the principally qualitative nature of the insights sought, interviews and workshops were considered as potential data gathering methods. Interviews were selected as it was believed these would be more effective at capturing the full diversity of participant opinion, whereas workshops would risk being dominated by more vocal participants. To effectively investigate the three preconditions within an interview of acceptable duration, and to ensure a sufficient degree of comparability between participant responses, it was decided that semi-structured interviews combining open and closed questions would be most effective. To facilitate interview navigation, the topic list that is typical for semi-structured interviews was augmented with a questionnaire built in Jisc Online Surveys that was shared on-screen and completed by the interviewer in discussion with participants during the interviews.

Participants were encouraged to expand on their responses to both open and closed questions so that additional unstructured insights could be captured. The combination of structured and unstructured data obtained via this approach provided rich insight, while keeping the interviews in most cases under 90 minutes in duration.

Participant recruitment

Three target participant groups were identified: 1) freight operators and shippers; 2) government and transport authorities; and 3) industry associations and experts. Within group 1, target sub-groups were supermarkets, third party logistics providers (3PLs) and food manufacturers. Within group 2, target sub-groups were national authorities (UK-wide and individual UK countries), regional / combined authorities, and local / city authorities. Group 3 included industry associations and experts. To provide sufficient representation of all groups and subgroups, a target of 30 participants was set. Ultimately,

37 participants were engaged in 32 interviews (see table 1).

Table 1: Participants and interviews per target group

Group	Participants	Interviews
Freight operators and shippers	17	15
Supermarkets	8	7
Third party logistics providers	6	5
Food manufacturers	3	3
Government and transport authorities	13	10
National (including devolved country authorities)	4	2
Regional and combined authorities	7	6
Local and city	2	2
Industry associations and experts	7	7
TOTAL	37	32

Applicability of findings to other road freight segments

While most operator/shipper participants worked within the selected road freight segment, other participants had a broader road freight remit, and their responses encompassed but were not always limited to this segment. This was considered legitimate in the context of the objective to test the three preconditions for purposive road freight decarbonisation. It means however that it is not always possible to say with certainty if a finding is specific to the selected freight segment or broader. Although in many cases wider applicability seems likely, further work would be required to confirm this.

Data analysis

Structured data

Structured data was downloaded as an Excel spreadsheet from Jisc Online Surveys and imported into Python using Pandas. Imported data was then processed into the required formats and presented graphically using Matplotlib.

Unstructured data

For each interview, an initial auto-transcription was downloaded as a Word file from Microsoft Teams. This file included timestamps which were used to identify the start time for each question response. Start times were entered into an Excel table and Python was used to split the auto-transcribed text into question responses, removing the embedded timestamps in the process. Additional automated cleaning was applied in Python to remove duplicate and filler words and redundant punctuation, spaces and line returns. The transcriptions for each question response were then manually reviewed and corrected, referring to interview recordings where meaning was not clear from the captured text. Once this was completed, Python was used again to create well-spaced and formatted PDF files, incorporating relevant complementary information from the structured data analysis. The PDF files were imported into NVivo and qualitatively coded, applying principles from grounded theory (Charmaz, 2006) through an iterative process of open, axial and selective coding (Williams and Moser, 2019).

Interview design

The interviews were organised as follows:

Open questions on decarbonisation opportunities and barriers

The purpose of these questions was to elicit un-prompted participant views prior to asking the subsequent closed questions.

Closed questions and discussion on 3 preconditions

1. Techno-economically feasible options able to deliver rapid and radical decarbonisation need to be available

A literature review was conducted to identify the decarbonisation opportunities that were presented to participants. Participants were first asked to select the decarbonisation opportunity categories that they considered to provide the greatest opportunity for rapid and radical decarbonisation. For each category selected, they were then asked to select the specific opportunities within the category that they considered most promising.

2. A shared understanding of the design choices that need to be codesigned is required

A combination of literature review and discussion with transport experts led to the identification of five categories of design choice that may require codesign for rapid and radical road freight decarbonisation: decarbonisation speed and scale, technology / solution selection, infrastructure planning and financing, transition incentives and institutional capacity. For each category, participants were asked to select to what extent they thought it was important that design choices were coordinated across multiple actors, and the geographic and sectoral levels at which coordinated decision-making was required.

3. A politically and socio-technically feasible codesign framework to make these design choices needs to be put in place

Churchman et al. (2023) conduct a systematic literature review and identify 24 potential socio-technical and political codesign attributes for purposive road freight decarbonisation. To test these conclusions, participants were asked to what extent they agreed or disagreed with each attribute statement. If they agreed or somewhat agreed, they were then asked if they believed that it would be a significant barrier to decarbonisation if the attribute was not true.

Findings

Techno-economically feasible options able to deliver rapid and radical decarbonisation need to be available

Participants in 29 of 32 interviews saw motive technology transition as a key decarbonisation solution and in 26 interviews battery electric was seen as promising for local and urban freight. Significant barriers were however identified for the transition to battery electric, including grid capacity and access, vehicle availability, support for early movers, resource sharing and concerns regarding battery durability and sustainability.

Motive technology preferences for long-haul HGVs and views regarding other decarbonisation opportunities varied substantially, with widely differing views on the feasibility of hydrogen, biofuels and mode shift to rail:

Hydrogen: “Whether it’s fuel cell or direct drive hydrogen, for me it’s the future for the longer distances.” (Operator/shipper #3) vs. “Hydrogen is more promising for, for example, aeroplanes where you have a whole system with big quantities, but not road necessarily ... It’s a very expensive technology to use in road.” (Government/transport authority #6)

Biofuels: “That’s why things like biodiesel, particularly HVO, is so powerful, because with HVO you haven’t got to touch the vehicle or the refuelling mechanism.” (Operator/shipper #2) vs. “For biodiesel and biomethane, there are options that we’ve looked at, for example, HVO. We walked away from HVO because it’s more expensive and there’s a challenge around how that fuel is manufactured.” (Operator/shipper #11)

Mode shift to rail: “The way we’re tackling it, mode shift is our biggest opportunity in the long term. We’ve already made decisions about the position of the new DC.” (Operator/shipper #10) **vs.** “I’d never build my business on the idea that it was going to get somewhere by rail. You only have to look at what’s going on at the moment.” (Operator/shipper #8)

Fourteen supportive views regarding improved load and schedule optimisation at a network level were expressed, but substantial collaboration challenges were also raised. Electric road systems were seen by more participants as not feasible than feasible (10 non-supportive vs. 5 supportive views), primarily due to the large up-front infrastructure investment required and concerns regarding the practicality of catenaries over motorways and trunk routes. Other solutions including vehicle efficiency improvements, supply chain reconfiguration and consumer behaviour change were broadly seen as providing only incremental road freight decarbonisation benefits for the defined road freight segment.

A shared understanding of the design choices that need to be codesigned is required

Design coordination was identified as “critical” or “very important” in between 62% and 96% of interviews for the five pre-identified decision categories, with “decarbonisation speed and scale” and “technology / solution selection” seen as most critical.

Regarding decarbonisation speed and scale, there was consensus that clear decarbonisation targets had been helpful and galvanised action. Uncertainty in the strength of future government commitment to decarbonisation and risk of back-tracking was however seen as an issue. With respect to technology and solution selection, the availability of more than one potential motive technology winner for long-haul and heavy-duty applications was considered unhelpful, with the “VHS / Betamax” dilemma being frequently cited.

Uncertainty regarding infrastructure availability and the chicken and egg dynamic between infrastructure provision and new technology adoption were seen as major transition hindrances. A mixture of public and privately funded infrastructure was seen as likely to be necessary, but coordinating infrastructure planning across multiple authorities was identified as a challenge. There was broad consensus that incentives were necessary to neutralise some of the cost penalty of new technologies and to reduce risk for first movers, but differing views on what form incentives should take. Geographic alignment of incentives was seen as important, while recognising that local incentives and funding can also play a role. Key institutional capability gaps were identified by freight operators / shippers and government / transport authorities in areas including strategic planning, vehicle and driver licensing, vehicle standards, maintenance and safety, and land and infrastructure planning.

In addition to the decision categories that were identified prior to the interviews, alignment of policy across devolved authorities was seen as necessary by most operators / shippers and industry associations / experts who expressed a view. Education and training were also identified by some participants as important.

Unstructured responses reveal underlying differences of opinion in the extent to which it is possible or desirable for the government to drive or guide the transition via incentives or decision making. These differences are illustrated by the following contrasting quotes:

Speed and scale: “I firmly believe that in order to decarbonise, you’ve got to try and be the best you can at the point in time you’re at.” (Operator/shipper #7) vs. “It’s critical that we know what speed we’re going at and how much we have to achieve. There has to be that policy direction that everybody can follow.” (Industry association/expert #3)

Technology / solution selection: “The market should be allowed to evolve, to innovate, and sometimes it just needs that freedom. I would suggest, with developing technologies, coordination smacks of a command-and-control situation.” (Industry association/expert #6) vs. “And then having a real industry alignment, at least at the European level, that this is the route we’re going down for HGV. It’s mandated that either it’s electric, it’s hydrogen or it’s some form of other fuel that reduces carbon.” (Operator/shipper #1)

Incentives: “Incentivising the transition is largely going to be driven by the sector themselves when they have confidence in the technology having been demonstrated to be effective for their needs.” (Government/transport authority #1) vs. “Although the business case can be positive with alternative fuels, your capital cost is higher ... and therefore you need more funding in order to make it happen.” (Operator/shipper #5)

Policy: “Ultimately, big operators will manage this transition quite well. Others might not make it at all, and I think government has a question, does it care? As harsh as it sounds.” (Government/transport authority #2) vs. “Given the scale of the costs involved that only big business can afford ... only the government can make sure this level playing field emerges [for smaller operators].” (Industry association/expert #6)

The tension between these opposing views is a key finding. While some participants felt that it was necessary for government to make key design choices, others saw this as highly undesirable. This raises important questions regarding the appropriate codesign framework and how road freight decarbonisation should be governed.

A politically and socio-technically feasible codesign framework to make these design choices needs to be put in place

Potential priority codesign attributes: Where, in at least 75% of interviews, participants agreed or somewhat agreed with the attribute statement and believed it would be a significant barrier if not true. The nine attributes falling into this category are:

- Actors require incentives to take on additional risk
- Incumbents and new entrants should both have incentives to innovate and support the transition
- Asset and contract lifecycles must be considered
- Business risk and dependencies must be understood to identify feasible options
- Collaborative mid-range planning is required in addition to long-range visioning
- Infrastructure provision and spatial planning must be prioritised
- Need to consider supply security and price stability as well as transition effectiveness
- Policy needs to reduce uncertainty
- Authorities and departments within authorities need to align

In addition to meeting the above quantitative criterion, these attributes are qualitatively identified in unstructured commentary as important for rapid and radical decarbonisation. It is therefore proposed that these are considered as core design principles for the codesign framework for decarbonisation of this road freight segment.

Potential sources of conflict: Where, in over 25% of interviews, participants did not agree or somewhat agree with the attribute statement. The four attributes falling into this category are:

- Incumbents should not feel punished
- Sources of legitimacy other than decarbonisation itself are required
- It is important to consider political windows of opportunity
- Need to connect to a clear political idea and the political context

Further illustrating the potential conflicts from unstructured question responses:

Incumbents should not feel punished: “Completely disagree. They need to be made to feel like pariahs. It’s the only way they’re going to do anything about it.” (Industry association/expert #7) vs. “If you’re going to punish people for not having made the change and create an artificially favourable environment for people who have got the new technology, then there’s quite a risk to the whole market because there will be organisations that have already made enormous investments in what they currently do.” (Operator/shipper #8)

Sources of legitimacy other than decarbonisation itself are required: “You shouldn’t need to bring in anything else. There’s more than enough to say: ‘get off your backside and do something’.” (Operator/shipper #13) vs. “You do need a broader focus than decarbonisation. It also needs to be articulated in terms of green growth or levelling up or other social aspects. There needs to be an economic and the social dimension.” (Industry association/expert #3)

It is important to consider political windows of opportunity: “If we’re serious about decarbonisation, political windows of opportunity don’t come into it.” (Industry association/expert #6) vs. “You do need to be aware of the cycle of political opportunity. Certain decisions are easier to take earlier in a political term than others.” (Government/transport authority #2)

Need to connect to a clear political idea and the political context: “I don’t see it in any way as being essential because it’s such a hideously difficult thing to do.” (Operator/shipper #13) vs. “In the sense that everything is politics, it’s impossible to divorce these kinds of decisions from the political context. So, without a clear political direction, then yes, these things tend not to get off the ground.” (Government/transport authority #2)

Potentially lower priority: The 11 remaining attributes fell into neither of the above categories.

For these attributes, while most participants agreed with the statement, there was not a clear consensus that they would be a significant barrier if not true. For this reason, it is proposed that these are considered as lower priority for the codesign framework.

Key challenges

Key challenges, each identified in at least 10 interviews, are technology uncertainty and immaturity, lack of a clear direction or plan, lack of strategic infrastructure planning or funding, infrastructure chicken and egg, inconsistent incentives and policy, first mover disadvantage and up-front cost, and collaboration barriers.

Discussion and conclusions

The need for codesign

There was consensus amongst participants that motive technology transition and/or mode shift to rail are necessary for radical road freight decarbonisation. Other decarbonisation levers, while potentially being complementary to these, were not on their own seen as being able to deliver an outcome compatible with achieving net-zero by 2050 or sooner. Participants see clear decarbonisation targets and the upcoming Zero Emission Road Freight Demonstrations as helpful, but uncertainty in future government commitment to decarbonisation and the fact the high-level targets are not supported by detailed delivery plans and supporting policy undermines confidence. The challenges of centrally managing the transition are recognised by participants, with a full spectrum of views on whether this would be the right or wrong thing to do. The fact that most participants felt collaborative decision making was “critical” or “very important” across decision categories indicates an underlying belief that market forces influencing individual organisation action are insufficient to make decarbonisation happen at the required pace.

If centralised planning and individual organisation action are eliminated as mechanisms for decarbonisation delivery, the only apparent remaining option is codesign of key decisions by actors with the required collective knowledge of the freight transport system and the ability to execute the decisions made.

Codesign tensions

If it is agreed that codesign of certain key design decisions is necessary, the existence of trade-offs and potential sources of conflict must be considered. This study has identified the following tensions that could contribute to these:

Techno-economically feasible options able to deliver rapid and radical decarbonisation:

- Opposing positions regarding hydrogen, biofuels and mode shift to rail
- The benefit of keeping emerging technology options open vs. proceeding rapidly with solutions that are already proven at scale
- Whether incremental decarbonisation options should be considered

A shared understanding of design choices that need to be codesigned:

- Top-down vs. market-led approach
- The use of direct incentives to freight operators vs. demand incentives driven by freight customer requirements
- Whether a level playing field for smaller operators is required and feasible
- Centralised vs. devolved policymaking

A politically and socio-technically feasible codesign framework to make these design choices:

- Whether additional sources of legitimacy are required
- Whether incumbents should feel punished – carrot vs stick
- Whether road freight decarbonisation planning should consider political windows of opportunity
- Whether it is necessary to connect to a clear political idea and the political context

Codesign requirements and feasibility

If it is accepted that a) codesign between policymakers and industry participants is necessary for rapid and radical road freight decarbonisation and b) system and path dependencies mean that individual design choices cannot be considered in isolation, a codesign pathway is needed that defines the sequence and timing of design decisions. Such a pathway would need to be specified based on a clear understanding of system dependencies and have the support of a critical mass of industry participants and policymakers. For both reasons, it is necessary that the pathway is itself codesigned by relevant actors with the required system understanding and ability to represent and make commitments on behalf of their respective organisations.

Assuming that it is possible to define a codesign pathway, the codesign approach needs to enable decisions to be made in a way that achieves sufficient collective buy-in and is robust to scrutiny and challenge, particularly as there are likely to be winners and losers from each decision. Governance, collaboration rules and decision support tools are all necessary components of the codesign framework that will be required to enable effective codesign. This study concludes that the codesign framework will also need to embed priority codesign attributes and have mechanisms to manage identified codesign tensions.

While many industry participants and policymakers may agree in principle to a collaborative approach to road freight decarbonisation, translating this into a collective commitment to a shared codesign pathway and framework presents a formidable challenge. Industry participants work in highly competitive environments with tight margins and finely honed supply chains. There will be winners and losers from codesign decisions, and it would be naive to assume that potential losers will not do all they can to resist these. National, regional and local authorities are also key actors, and each of these have priorities and policies that are not always aligned either to each other or with the goal of rapid and radical road freight decarbonisation. A codesign approach will therefore need the backing of relevant authorities and key industry participants to provide necessary legitimacy and authority. The feasibility of codesign will to a large extent be dependent on whether this condition can be met.

Applicability of codesign to other road freight segments

GB food deliveries to supermarkets and supermarket DCs was selected for this study because of the volume of road freight that it represents and the concentration of large road freight operators and shippers that may make a codesign approach more feasible. Other industry sectors representing a large volume of road freight that have a high concentration of participants are metal ore, mining and quarrying; coke and refined petroleum products; non-metallic mineral products including glass and cement; and chemical products (GOV.UK, 2021). Each of these sectors would need to be considered individually to understand specific road freight decarbonisation opportunities and barriers, and the feasibility of a codesign approach.

In sectors with a greater number of smaller participants, it is possible that industry associations would need to act as a proxy for the hundreds or thousands of freight operators and shippers. Codesign could also be centered on freight nodes such as ports or industrial clusters. Further work focused on these segments is required to determine if such an approach could generate feasible decarbonisation pathways compatible with net zero goals.

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RESILIENCE AND RELIABILITY IN THE EXPEDITIONARY SUPPLY CHAIN

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Introduction

The United Kingdom's military strategy requires a global presence to support Global Britain. This imposes the requirement to create Expeditionary Supply Chains (ESC) to support the globally deployed military force. These SC will need to balance the requirements imposed upon it. They will be asked to provide an efficient, reliable and cost-effective SC governed by strict budget requirements, whilst also providing a resilient response where the performance of effectiveness is prioritised to the detriment of efficiency. This paper explores how the balance between resilience and reliability is achieved leading to competitive advantage.

Review of the Literature

Recent developments in military thinking have seen the role of logistics come to the fore as both the commercial and ESC have been exposed to disruptive events. This position is summarised through the somewhat ubiquitous Volatile, Uncertain, Complex and Ambiguous analysis of the environment (Wilding, cited in MOD, 2022). To address this a growing wish to build resilience and reliability into logistics operations to fix the "...fragile nature of SC..." has become an established position (Hutchings, cited in MOD, 2022, 2). This is reflected beyond the UK military and has been embedded into western views. The 2023 release of a new US Marine Doctrine (2023) echoes this. Arguing for the role of continuity of logistics in contested areas and its role in offering limitations and opportunities. Such views are echoed for the US Navy (Luebke et al., 2023), the Australian military (Logistic in war, ND) and NATO in the new draft Doctrine (NATO, 2023). Additionally, the academic view also supports such positions typified by Kane (2006,1) and Martin (2016, 75) who argue for logistics to be the "Arbiter of Opportunity" to the military strategist. Consequently, there is a strong argument for the role of building resilience into the military supply chain. Indeed, there is a call for a "...paradigm shift..." in the UK Support Chain (MOD, 2020,16).

However, little is articulated about how to achieve such a paradigm shift within the context of Supply Chain Management (SCM). A generic SC combination strategy is offered as the panacea (MOD, 2023) adopting much of the insight of the combination of lean and agile SC. This reflects the principles of the Leagile SC (Mason -Jones et al., 2000) and hybrid model (Christopher, 2016) of SCM. For the MOD this is a bimodal SC with Mode 1 based around business as usual and Mode 2 reacting to a shock to the SC (MOD, 2023). Thus, clearly identifying a decoupling point reflecting a change in the SC performance measures from efficiency in Mode 1 to effective in Mode 2 (Smith, 2018). The bimodal SC then develops the ability of the SC to be resilient and reliable while balancing additional measures such as cost, service and environmental sustainability (MOD, 2022). At the aggregated macro level this offers a SC strategy but offers little detail in how it will be achieved within SC practice.

To develop a practice based view there is need to understand the construction of the UK ESC. Embedded into this is a task orientation model which accumulates the required logistic enablers to construct a ESC to support the required military effect (LWDC, 2017; Fighting Instructions, 2017). This is a doctrinal bureaucratic approach drawing on established positions and knowledge to meet a planned demand. This position echoes much of the historic military literature surrounding the creation of military logistics. It can be seen as a scientific approach (Thorpe, 1986; Kane, 2006; Kress, 2016; Martin, 2016) where resources are created, oriented and organised to meet an established forecasted requirement. However, the nature of military

action established through the cliched phrase "No plan survives contact with the enemy" needs to be accounted for (Attributed to Helmuth von Moltke (The Elder), 1800-1891). In this position the planned bureaucratic ESC needs to be adaptive to meet external contingencies placed upon it (Pagonis, 1992; Van Creveld, 2007; Kane, 2016,) seen as the art of logistics. This is the ad hoc nature of teams of logisticians reacting to a contingent situation by modifying the ESC appropriately to maintain the support needed to deliver the military effect (Tuttle, 2005; MOD 2020; MOD, 2022). Such views are embedded into historic thinkers such as Van Creveld (2007). Returning to the Defence SC strategy these positions would reflect a Mode 1 SC as being relatively bureaucratic while Mode 2 being more flexible and reactive with an ad hoc nature. This creates a challenge. How does an ESC move from one dynamic position reflecting a Mode 1 focus on efficiency to a Mode 2 SC reflecting an ad hoc approach and drive for reliability and effectiveness. For this work the movement between these two dynamic positions creates insights into how resilience and reliable ESC are created.

The Challenge

Accepting that a bimodal ESC approach is being developed by the military as a means to create resilience and reliability the question becomes how this can be achieved in practice. This is moving past the macro level SC strategy to articulate the practise carried out by military logisticians to enable them to move from one ESC position to the next. The challenge is both theoretical in understanding the conceptual positions that underpin this movement and identifying the practical activities which are needed by the logistician to carry it out.

Research Approach

In answering the call from SC researchers for qualitative investigations which seek the why of the SC phenomena (Mangan et al., 2004; Burgess et al., 2006) this paper adopts an exploratory qualitative focused investigation created through the systematic approach of Grounded Theory (GT). GT represented the most appropriate research paradigm enabling the reality of the SC to be captured from those individuals and groups of individuals participating within the SC. This aligned to the research philosophy of Subjectivism and the role of the individual within the military SC enabling resilience and reliability (Attride-Stirling, 2001; Mangan et al., 2004; Braun and Clarke, 2006; Howitt, 2010) Analysis of the resulting data was through thematic analysis, within NVivo, and captured the tenants of GT. The result was a dynamic interaction between the data, the theoretical positioning and the creation of the conceptual positions (Suddaby, 2006; Charmaz, 2014).

Data was collected through an abductive approach (Charmaz, 2014) consisting of two iterations. The first, inductive, iteration based on a 3 round Delphi survey developed a conceptual framework to answer how, what and where the military SC was constructed. The Delphi engaged with a total of 286 respondents from the UK military and civil service, academia and defence SC industry. The result articulated a consensus view of the themes explaining the ESC. These themes were consolidated into a conceptual model of the ESC emerging and ground it in the data collected.

The second iteration was deductive and tested the conceptual model through 10 intensive interviews (Charmaz, 2014) with practitioners selected via theoretical sampling. These practitioners were all embedded into the ESC at points in which decision-making and ad hoc responses were constructed in response to external contingent actions. The result was a development and confirmation of the ESC conceptual model.

The Conceptual Model

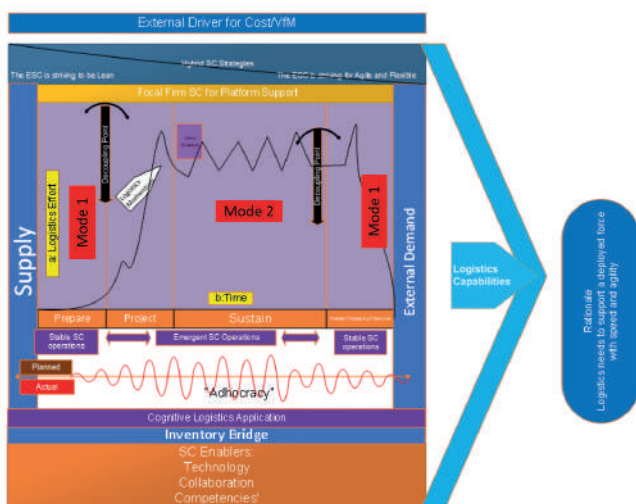


Figure 1 The Military SC Conceptual Model

Articulated in Figure 1 is the resulting conceptual model explaining the construction of the ESC. It identifies the rationale for the ESC and the external drivers of cost and value for money being applied. It shows the bimodal SC of lean efficiency twined to agility and flexibility through Mode 1 and 2 SC. This is then linked to the military life cycle of prepare, project, sustain and recover. It matches this to logistics effort and time to show a project life cycle with logistics effort demonstrating the demand placed on the SC and the points of decoupling of the SC approaches. It then goes on to articulate the movement from stable

to emergent positions where the planned SC deviates from the actual SC through the role of adhocracy. The model shows a bureaucratically constructed planned SC (Mode 1) and the consequential interactions with external contingencies as the SC is developed (Mode 2) to meet the new demands placed upon it. It demonstrates a SC in flux as it deals with the dualities of stable and emergent, planned and unplanned, resource focus versus contingent focus and bureaucratic and ad hoc. The conceptual model concludes by offering logistics enablers that create this military SC including the role of cognitive logistics and its application to the SC. The totality of these positions culminates to create the logistics capabilities that deliver the ESC. Having identified the conceptual framework, it is now important to explore how the movement from one SC position to the next imposed by the dualities demanded of the SC are dealt with through a theoretical lens.

Theoretical Position

The work starts by considering the doctrinal and bureaucratic approach of the construction of the military SC through the amalgamation of resources into task groups. Swanson (2017), and Wilding and Chicksand (2012) argues that the Resource Based View (RBV) is the most common theoretical position for Logistics and SCM. The foundations of RBV can be seen emerging from strategic management as it challenged the dominance of market analysis in creating competitive advantage (Johnson et al., 2011; Lynch, 2018). This moved the focus away from the external industrial context to the industrial organisation. The internal focus created views of the role of resources and their combination to achieve competitive advantage (Barney, 2002; Hunt and Davis, 2012). Original views of RBV considered both tangible and intangible resources and their combination. Such views were challenged and developed to be able to consider competencies or capabilities (Teece et al., 1997). This was the combination of resources and their direct application to give sustainable competitive advantage. This offers a robust foundation to understand how the ESC organisation structure can be adapted to meet the external contingencies. It acknowledges the internal view of the role of resources and more importantly the role of combining these resources into the unique project life cycle (MOD, 2015; LWDC, 2017). The conceptual framework shown in Figure 1 reflects this both as cognitive logistics as well as competencies embraced across the model. The theory also needs to account for the ad hoc nature of the ESC this is applied through the prism of Dynamic Capabilities Theory (DCT). DCT emerges from the RBV of the organisation (Teece, 1997, Lynch, 2015). DCT argues that stable resources such as core competences offer a short/mid-term advantage (Teece, 2018a, 2019). While they offer a valuable contribution to gain competitive advantage they can be easily replicated over the medium term. DCT recognises this position. Andreeva and Chaika (2000,10) see DCT as "...dynamic capabilities [offering] a certain set of organisational properties that provides the renewal of core competences. Renewal is a useful concept which reflects the need for dynamic reconfiguration. This would suggest a reinterpretation of a core competency to meet a newer competitive position. This offers a meta position where DCT is not articulating the creation of individual named core competencies at what Teece and Linden call the "micro foundations" level (2017, 40) it is the identification of competencies to create dynamic environments for the creation of individual named core competencies. DCT can be seen as the competency of competencies. According to Teece et al this is the "Ability to integrate, build, and reconfigure internal and external competence to address rapidly changing environments." (1997, 516). This the reconfiguration of the ESC to meet the unplanned contingent event.

Figure 2 combines these positions. The Figure shows the movement in the ESC between misfit, quasi-fit and fit through these dynamic capabilities to meet the dualities imposed on it such as being efficient and or effective. A line of fit is suggested as the "perfect SC" position reflecting achieving the balance of effective and efficient in a stable SC environment. However, in an emergent SC environment the ESC reacts to different and often competing demands at different times and so is in constant flux. This creates the movement of the SC approach being applied to the ESC from efficient to effective or vice versa. It is this movement, labelled as dynamic capability, at the operational strategy level which is the core skill to build resilience and reliability. Thus, it is argued that the dynamic capability is not an individual core competence but the meta-ability of creating environments where reconfiguration of the ESC is enabled at a higher order level of competencies.

Thus, for the ESC, the higher order dynamic capability can be seen as adhocracy. For this debate this is the competency to reconfigure the ESC to address rapidly changing external contingent events in an ad hoc manner within an internal bureaucratic structure articulated within the combined phrase of adhocracy. While this does offer a framework for the movement between misfit and fit to support the ESC some articulation of the process to achieve this is needed to represent a practitioner and pragmatic perspective.

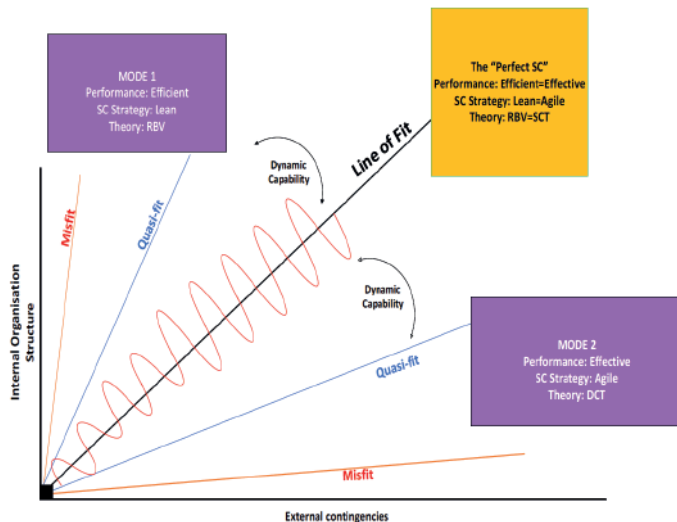


Figure 2 Fit and Misfit in the ESC

To do this the work draws on Teece (1997, 2017, 2019) and his development of DCT. Teece is seen as one of the original authors of DCT and offers a longitudinal development of the ideas and concepts (Andreeva and Chaika, 2000). Figure 3 reflects the combination of the core concepts of Teece (sense, size and reconfigure) and their application to the ESC. It reflects a pragmatic response to the ability of moving the ESC from misfit to fit. It is the practitioner model to support addressing flux in the ESC. It is the tool to move from Mode 1 to Mode 2.

Figure 3 articulates the starting position with DCT which is reconfiguration for a purpose (3a). Helfet (2009) argues that reconfiguration in support of dynamic capabilities is not completely ad hoc but responds to the needs being placed upon it. It creates a dynamic configuration to support an identified purposeful need. For the ESC this is dealing with external uncertainties being imposed on it. The next position of sense (Figure 3b) builds this external viewpoint. For Teece sensing the external position is an important element of higher order dynamic capacity reflection. For the ESC it is identifying new external contingencies so that the internal configuration can be aligned to the new position. Across the literature this is often linked to the development of the opportunities and threats embedded into external contingencies (Funival et al., 2019).

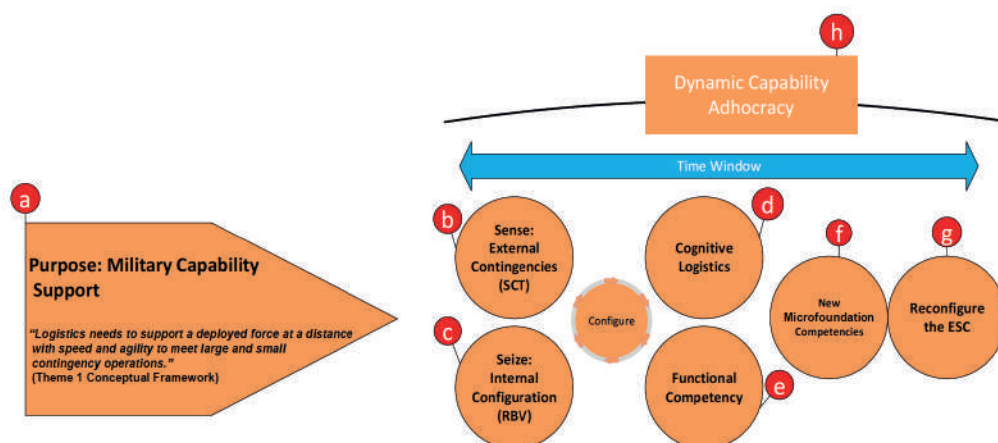


Figure 3 Dynamic Capability Building Based on Teece's Work (1997 – 2019)

While seize (Figure 3c) is a reflection on internal configuration and the ability to configure to achieve congruence with a changing external environment (Teece, 1997, 515). It reflects the strengths and weaknesses created from an internal RBV perspective. For Flynn (2016) and Beske (2012) external SC partner competencies are also reflected. This is the ability to gain advantage from the combination of internal with external competencies held across entities within the ESC. Within the UK, and the wider Defence community post Ukraine, this is the Whole Force approach linking industry and the military into a coherent whole (MOD, 2015, MOD, 2023). The combination and configuration of the internal and external competencies

can be seen as the orchestration (Teece, 2018) of resources to fit the external contingencies. The configuration of resources is also articulated within military doctrine (MOD, 2015; LWDC, 2017) and the creation of task groups to meet objectives (Smith, 2018). Within the conceptual framework it is shown as collaboration (Figure 1) which offers a significant capability.

The role of sense and seize lays the foundational position for the application of cognitive logistics (Figure 3d) (Van Creveld, 2007; Kress, 2016). This is the knowledge, experience and attitudes of the individual logistician and their organisation. It creates the reflective stance of understanding the dynamic position to begin to configure (Andreeva and Chaika, 2006) the ESC. It builds on both the tangible and intangible. The tangible being the processes articulated in the bureaucracy of military doctrine and practice (Pagnois, 1992). While the intangible becomes the individualised knowledge of the logistician and their application of the tangible process (MOD, 2022). The point resonates with the uniqueness of each application of the ESC and the need for adhocacy. While cognitive logistics offers the reflective position, functional competencies (Figure 3e) are those that deliver the day-to-day logistics activities of the ESC.

The flux of the movement between misfit, quasi-fit and fit (Figure 2) does not represent a single position or point in time it is a dynamic position. It is not a linear formulaic approach. The configure symbol within Figure 3 reflects this iterative approach of sensing the environment and seizing the configuration opportunities based on the cognitive and functional competencies within the ESC. Therefore, the flux and the process of configure allows new microfoundation competencies to be created (Figure 3f). This is the bundling of the support enabling resources to create the task group and thus the logistics competencies and organisational structure. This leads to the final position of Figure 3g reconfiguring the structure of the ESC into the task group format to achieve the performance outcomes demanded of the dualities imposed on the ESC.

The combination of these activities leads to the meta position of DCT. This is the higher order competency building (Figure 3h). This is not about the individual competency but the creation of an environment for the creation of new microfoundation competencies and their configuration to meet performance outcomes. It is this dynamic capability captured through configuration which is articulated as adhocacy within the Conceptual Model Figure 1. Embedded into the vocabulary of dynamic is the inference of speed and ability to react. For the ESC the time window reflects a dynamic position (Figure 3). Here the time window is opened on the deployment of the military force until it achieves its stated objectives: a project lifecycle SC (Figure 1). For example, a contingent operation might be based on unforeseen circumstances and need to react instantly and last only days. Operation Pitting (2021), the evacuation of Afghanistan is an example of this. Likewise, a sustained operation such as that of supporting troops in the Baltic might be seen over years, reducing the dynamic impact and uncertainty. As a consequence, the time window shows the increased or decreased need of adhocacy as a dynamic capability. For example, in the prepare (Mode 1) stage a long-term view would show less impact of contingency and therefore fewer dynamic capabilities being applied. While during the project stage (Mode 2) where external contingencies and uncertainties are impacting the design of this ESC configuration the need for dynamic capabilities will be more important. This can be seen in the steep climb of logistic effort shown in the conceptual framework (Figure 1) as logistic momentum. It is therefore argued that dynamic capabilities articulated as adhocacy becomes the technique to enable the ESC to function within its required macro SC position of Mode 1 and 2. It is this dynamic capability which addresses the challenges imposed on the ESC to be all things to everyone. It offers the ability to develop a SC which caters for cost effectiveness through efficiency while being able to move, with little notice, to be effective within rapidly changing contexts. It is adhocacy which offers the practical steps to change the ESC paradigm and delivery support advantage through being reliable and resilient.

Discussion and Conclusions

Argued at the beginning of this paper is the need to build ESC to be reactive to contingent external events. This is argued as the new norm within the Defence SCM environment (MOD, 2022). The ESC, according to the Defence SC Strategy must be able to move from a less dynamic and stable position where the focus is on efficiency (Mode 1) to a dynamic SC able to meet unforeseen contingent events where the priority of efficiency might be sacrificed for the need for assured and reliable logistics provision (Mode 2). To enable this movement the SC needs to develop dynamic capabilities to enable the ESC to reconfigure and align to the new demands and contingent events. While this is identified at the macro level within the military literature no practise has been outlined to enact this dynamic movement from Mode 1 to Mode 2. This paper has argued to do so requires establishing resilience and reliability into the SC. To enable this position a SC needs to be able to deploy its tangible resources to deliver the demand placed upon it. In doing so it must plan to deploy these tangible resources to fit the contingent environment it finds itself in. This combination draws on the need to balance many dualities imposed upon it including constant flux as the situation changes.

Thus, this paper argues the adhocracy is the technique to build resilience and reliability into the ESC so that the military commander can take advantage of any opportunity presented to them. Only a military which has the logistics capability to react and overcome contingent events will be able to allow the commander to avail themselves of every opportunity. It is this logistics capability that offers support advantage to the UK military. To gain this support advantage military logisticians should apply the dynamic capability technique of adhocracy as the new military supply chain paradigm.

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AN INVESTIGATION OF THE FACTORS AFFECTING EMPLOYERS' ATTRACTION AND RETENTION STRATEGIES IN GROCERY SUPPLY CHAINS

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1. Introduction

According to the Confederation of British Industry (2022), labour shortages across supply chains have presented a new challenge recently, thus many UK companies have responded by training, and/or increasing pay to retain workers and attract new recruits. Global social and political events are at the root cause of this challenge, examples of these events are COVID outbreaks (Hobbs, 2021), Brexit (Pocock, 2021) and a new status quo of "intense competition for workers" (Butler, 2022). It is supported that it is even more difficult to recruit in some sectors such as hospitality and food retail supply chains that considered as "undesirable" sectors (King et al., 2021).

Food retail is a sizeable industry in the UK with 2.2 million people, in 2021, and it is considered a critical infrastructure activity. Recruitment and retention of employees within the grocery supply chains is therefore a crucial activity. However, food retailers and suppliers cannot attract and retain quality employees which has a severe impact on their businesses (Nelson, 2022). Previous studies have focused on contexts other than grocery supply chains, for example Ghani et al. (2022) that focused on the hospitality industry and Radford and Chapman (2015) that explored the care worker industry. However, various interrelated internal and external factors affect employee attraction and retention, and that it is necessary to apply a specific level of context to each sector in order for resulting recommendations to be useful (Sinha and Sinha, 2012). Thus, this study fills the existing research gap by attempting to explain the factors that are currently affecting recruitment and retention ability and then offering practical solutions. The aim will be fulfilled by investigating the following research questions:

- What are the internal and external factors that lead to employee attraction and retentions strategies?
- How are these factors affecting the attraction and retention of employees in grocery retail supply chains?
- What are the strategies that can be applied for attraction and retaining employees in grocery retail supply chains?

The remainder of this paper is structured as follows. Section two analyses the methodological approach used to investigate the research questions. Section three provides an analysis of the key themes which have emerged from the case study. The paper concludes by summarizing the key lessons from the case study and describes the theoretical and practical implications.

2. Methodology

A single case study was undertaken to gain deeper insights of a leading UK supermarket (which has been renamed Company A to protect confidentiality). Case studies are based around answering "how" and "why" experiences and the research questions are well aligned as they try to explain certain phenomena in employee retention and the labor market, meaning they are well suited to case study. Semi-structured interviews, comprising 10 questions, formed the data collection of this research. The questions of the interview were based around key phrases relevant to the research objectives "employee attraction" and "employee retention", with 5 questions attributed to each key phrase. Interviews were conducted in person, on site, with logistics professionals and HR managers during March 2023. There were 2 HR managers and 3 operational managers, each of them held a different job title, meaning there was a great range of perspectives. In analysing the interviews, recurring themes were identified using thematic analysis, meaning that patterns, topics, and ideas that appear frequently amongst the results were sought, and from this "themes" generated (Braun and Clarke, 2022)

Responses	Sub-Theme	Aggregate Theme
"They need money" - Operational Manager B	Basic Pay	Direct Financial
"They've got a regular income" - HR Manager A		
"Some people work just basically for the payslip" - Operational Manager C		
"We've increased the freezer allowance. So they get the normal rate of pay that everybody gets as a warehouse logistics operative ... and then on top of that they get the daily freezer allowance" - Operational Manager A	Premium Pay	
"...we [are] giving extra [for] working late shift night shift" - Operational Manager B		
"They get the daily freezer allowance and that's recently been increased with the last pay negotiation" - Operational Manager A	Pay Negotiations	
"We would always look at what our competitive hourly rates look like"- HR Manager B		
"We have a local agreed union that will annually negotiate their pay. This year they negotiated a 7% increase, so the pay is definitely a massive driver" - HR Manager B		

Table 1: Direct Financial Compensation Theme

3. Findings

This section presents the findings produced through the interviews and highlights the themes that emerged about employee attraction and retention.

3.1 Retention theme: Direct Financial compensation

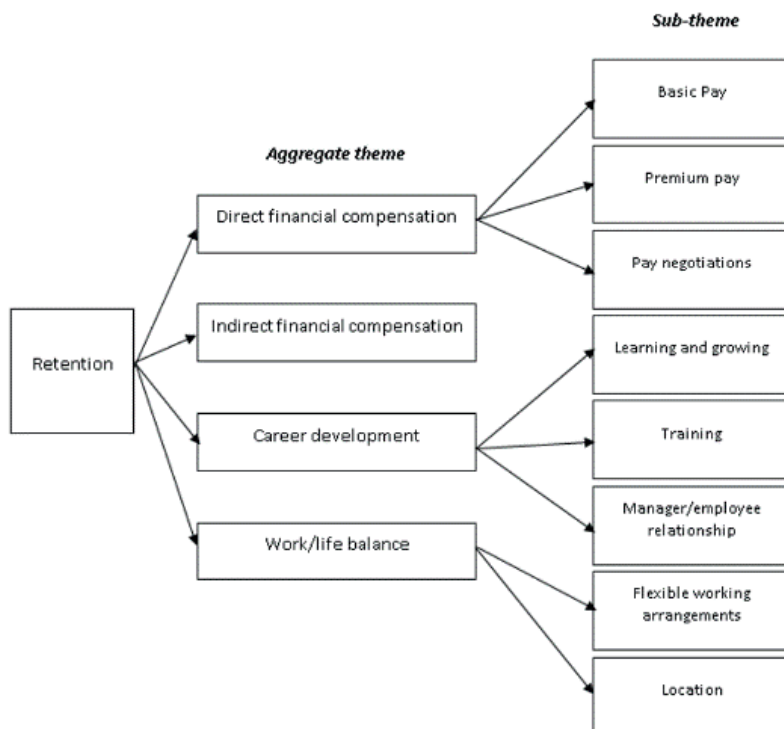


Figure 1 provides a visual breakdown of the themes described below about retention.

Respondents indicated that wages are one of the main reasons that employees stay with the business. They described how the pay, made up in several different forms, was generally perceived as competitive, and how maintaining this competitiveness was important. Simply put, Operational Manager B answered, “they need money”, the necessity and regularity of the pay was another aspect that retained employees. Below, the table 2 depicts the different dimensions of the direct financial benefits theme, and the responses that established these themes. The findings suggest then that pay is an important driver of retention, and the strategy generally employed is to retain a competitive overall direct pay offering.

When questioned on what internal and external factors create this strategy, the recent cost-of-living crisis was suggested by one respondent, in the passage below: “Everybody’s thinking about money, you know. You and I sit here now, and we you know, have we turned our heating down at home, you know, have we got our heating on at home? It’s impacted everybody.” – HR Manager A It is evident that the cost-of-living crisis has put pressure on the company to offer higher wages in order to compensate with inflation, it seems increasingly important to employees that as an employer, the company recognises this challenge and pays them accordingly.

3.2 Retention theme: Indirect Financial Compensation

Several respondents identified indirect financial factors as an influencer on retention. The indirect financial reasons included anything that would not appear on a pay slip, but that benefitted colleagues, and which the respondents believed made them more likely to stay in their role. Specifically, several respondents spoke about sick pay, holiday pay, onsite, subsidised canteen, a staff discount card that could be used in the supermarket’s store, free onsite parking, and discounts at restaurants, cinemas, and other retailers. These benefits were discussed as supplementary to direct financial reasons for retention, with the strategy of creating a competitive overall package. HR Manager A believes that this overall package offered is effective.

“They don’t leave for rate of pay. The rate of pay is very, very competitive with lots of benefits that go with it. So the reasons for leaving are never around pay” - HR Manager A

3.3 Retention Theme: Work/life balance

The last theme from the retention questions was work life balance, these included the sub themes of flexible working arrangements and location (see Table 2). This theme appeared frequently in questions about the employees at the site, and the managers themselves who were being interviewed, indicating that this theme was crucial to staff retention. It seemed that the importance of having this balance has increased significantly in recent years, and employees now want work to not only be convenient in their life, but to fit around it, and the business seemed happy to accommodate this in several forms, depicted below. It also seemed to have a large impact on people leaving, many mentioned that those that leave are because they are leaving the area. One external influence identified on this was Brexit, which was reasoned to have led to many originally eastern European workers returning to their home country, as HR Manager A identifies:

“...over 54% of my workforce when I got here was Eastern European and a lot of those. Colleagues have gone back to their homes and haven’t returned to the UK.” - HR Manager A

Operational Manager A agreed with this, stating “quite a number of people went back to their own country.”.

Responses	Sub-Theme	Aggregate Theme
We've obviously had to have introduced different types of working as in the 4 x 10-hour shifts, so that the colleagues don't lose that weekly wage. But they have an extra day off - Operational Manager A	Flexible Working Arrangements	Work/life balance
"I'm staying with the business because it suits me personally as the Business was pretty flexible with my family balances" - Operational Manager C		
"They're a lot more flexible now. There's a lot more options... Some people start from 7 some people start from 8:00 o'clock because they need that one. Someone finish at 12... now we are definitely more flexible" - Operational Manager B		
"The distance I have to travel to work. So I work just three minutes away from where I live." - Operational Manager C	Location	
"I look at the data, for reasons for leaving, the majority of people leave for the leaving location." - HR Manager A		

Table 2: Work/life balance

3.4 Attraction Theme: Pay and Benefits.

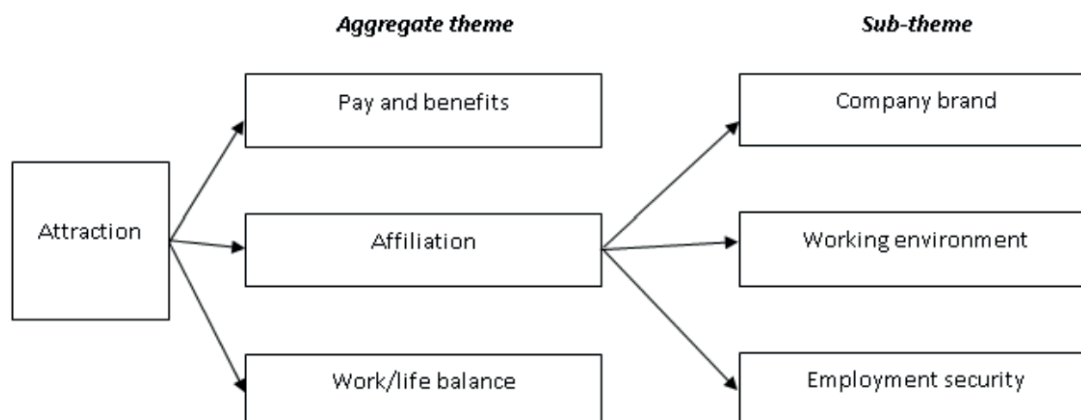


Figure 2: Attraction Theme Map

Similar to the financial themes for retention, the respondents repeatedly identified how the financial compensation of the job was an initial attraction to the job they applied for. Very often, rate of pay was discussed in relation to other warehouses in the local area, the warehouses compared to one another, one manager recounts how the opening of another warehouse offering higher pay lead to people leaving.

"I can't remember the name of this company, but definitely few people left because they offer more money." - Operational Manager B

Often, it was mentioned that having a strong rate of pay was of strategic advantage to their attraction efforts, one interesting point to contrary was made by a HR manager, who commented that the pay was not included on the adverts for the job. They emphasised other aspects, "when we advertise the profile, it will say what the hours are. It won't say what the actual pay is, but it will say what the hours are" - HR Manager B, whilst pay was important, they believed the initial attraction came from the business' other benefits, such as staff discounts and the subsidised canteen.

3.5 Attraction Theme: Work/life balance

Similar to the retention theme, the flexibility and convenience of roles were mentioned by several respondents as a factor that influences the attraction of potential employees to a job in the supermarket's distribution centre. When discussing this aspect, managers were conscious to mention that employees want flexible work arrangements, to work how many days they want, and to do what hours they want. They spoke about how, previously, there was very little in terms of working arrangements, and there was little flexibility outside of a three-shifts model. Now though, the strategy appears to be to aim to create an operation that is able to accommodate, within reason, whatever hours someone requests, HR manager A tells the researcher "We're not just a 6 to 2, a 2 to 10 and a 10 to 6 operation. We are a continuous pick operation. So if you're available for three or four hours a day actually you can come to work in a warehouse and pick products for three or four hours a day" - HR Manager A. The overall impression was that, whilst the company was not there yet, they had made significant progress towards achieving this objective. Specific examples of this increase in flexibility included 4x10 hour shifts, which gives "an extra day off" (Operational Manager A), and 32-hour contracts, instead of the typical 40 hours. The necessity of this strategy was attributed by HR Manager A to the external influencer of the Covid pandemic, "COVID has had an impact. COVID has made people think about things differently in their life".

4. Discussion

4.1 Discussion of attraction factors

Respondents spoke about the pay and benefits as a reason for attraction, the interviews specifically contained data about the overall package that was given to employees, and how maintaining this package as competitive was important for attracting potential new employees. Previous literature has also identified that financial compensation keeps employees with their employer, including BLR's (2014) identification of pay being made up of several different aspects, as was also found in the data. Moreover, Doane's (2009) argument that companies that operate in similar industries will offer similar overall compensation for a role was also supported by the data, with one respondent noting how even though pay structure may differ from warehouse to warehouse in the local area, there was, in reality, only small differences between the overall pay received.

Employee brand was another area that was found to be a contributing factor to employee attraction in both the literature review and the data. Several respondents identified that they believed the company had a strong brand, one that to potential employees represented job security and a high quality of working environment and had a positive influence on employee attraction. This finding agrees with Hughes and Rog (2008), being that a company benefits from having a strong company brand. However, Sangeetha (2010) argued that a company must try and match their culture to that of a potential employee, this was not mentioned by any of the respondents, indicating that this is not a part of their attraction strategy. Lastly, as one HR manager mentioned in the interviews, Covid made people consider their work/life balance a lot more, which is supported by the work of Partington (2021) who identifies that the expectation for flexibility around working times has increased since the pandemic.

4.2 Discussion of Retention factors

Pay is also an influencer on retention and is an area where this thesis' findings and the findings of other academics differ somewhat. HR manager A said that employees don't leave the business because of pay and found that most often it was due to leaving the local area. This contradicts Michael et al.'s (2016) findings, that pay is a major influence when employees consider staying in or leaving their job. Moreover, contrary to Bussin's (2014) argument, none of the respondents spoke of a pay structure that directly rewarded someone staying within the business, such as a sign on bonus. Interestingly, one manager spoke of differences in pay between managers, this kind of inconsistency in pay between equally experienced managers is an area where a company can increase their retention levels by ensuring that all pay is fair.

As argued by Keller et al's (2020) study, supply chains benefit in numerous forms by having committed workers and low turnover. It is clear from the data also that attraction and retention has provided a challenge to the managers and the site. It had also been clear from the respondents that they had been effected by Covid and Brexit and was the kind of company that Sumption (2022) identified as reliant on EU labour. According to Keller et al. (2020), this challenge could be extremely detrimental to the site and company as a whole. the respondents attributed the challenge differently, some mentioned a

change in expectations from workers, and that manual work is not looked on favourably, another mentioned how local competition from other warehouses is likely to increase. None of the respondents believed however that there would be a significant enough threat in attraction and retention that it would negatively impact their operational capability, however, it has been proven that supermarket shelves have been left empty at times due to labour shortages (Steve and Mason, 2022), perhaps signifying that there has been an improvement overall in the labour market. It is clear from the data and the literature review that supermarket supply chains are, perhaps more than average, susceptible to external influencers that effect their ability to attract and retain staff.

5. Conclusions and Recommendations

Strategies for improving retention must consider the recent general cost increase, and therefore focus on training and development, which can be improved without direct cost to the business, and is within the direct control of managers onsite, as opposed to pay which is dictated centrally. Training on the site allows for greater task flexibility, such as driving forklifts or loading lorries, which managers regarded as less manual than picking, which they identified as difficult work which had a poor reputation, it can therefore be assumed that higher task variety would lead to higher work satisfaction and high job commitment.

Recommendations for attraction strategy are for more exploration of flexible working patterns, allowing greater work/life balance and greater use of the new community role that was introduced, which influences the local perception of the supermarket. Whilst it was clear that the company was trying to innovate in these attraction strategies already, there was still a lot of potential to improve. These new strategies align with McRea's (2021) argument that companies must invent new ways of creating attractive jobs. In line with the research objectives, here it would be recommended that the company invest more into these new strategies in order to discover their fullest potential, especially the community role, as this is yet to appear in any literature on the topic and could be argued as an example of genuine innovation within the industry.

5.1 Theoretical Contribution

This study has aimed to contribute to the theoretical understanding of employee attraction and retention, specifically within the supermarket supply chain sector. Often, whilst attraction and retention factors were similar, it was about how the company communicated to either existing employees (for retention) and potential employees (for attraction). For example, existing employees found that the union negotiated pay rises has an important part of the overall compensation, whereas the benefits of the role are emphasised to potential employees. It is possible to conclude from the findings that pay, and benefits are powerful tools that can be utilised to improve attraction and retention, and it is not as simple as paying a high hourly rate. Moreover, the findings suggested that the reasons for joining and staying with the business were varied, but stand-out influencers included training and development, the opportunity for work/life balance. There is a potential for these findings to influence the retention and attraction strategies of supermarkets within the UK, and for them to adapt their strategies to consider the findings.

5.2 Managerial Contribution

This study has contributed to the management of attraction and retention by offering realistic and practical recommendations that managers can implement in order to improve attraction and retention. The study also revealed that perspectives on the issue are varied and nuanced and are heavily influenced by the role of the manager and their experience. Despite these difference however, there was some aspects of attraction and retention management that were present across all managers, and perhaps represent some form of success on the part of the supermarket that all managers agreed on at least some aspects, those being: building the employee/manager relationship, the necessity of a competitive pay packet, and the strength of the company brand.

5.3 Limitations

The most significant limitation to this research is scope. The research has only been conducted with one grocery retailer, which acts as one part of the supermarket's supply chain. The research therefore fails to consider how different supermarkets, perhaps with different priorities, may approach retention and attraction with different strategies. Moreover, the recommendations to improve on the current strategies are limited in their utility due to the fact they have been limited in their application and testing.

5.4 Future research

The original plan for this thesis was to have studied three different supermarkets, creating three case studies and cross-case analysing each, which would have created more valuable findings and therefore more valuable recommendations. Due to time constraints, this was not possible, but the researcher recommends that future research into this topic is conducted in this way. Moreover, the inclusion of respondents from different areas of the supply chain, for example manufacturing, store or head office would have created a broader and more practical assessment of employee attraction and retention in the grocery industry.

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MODELLING BACKHAULING OPERATIONS THROUGH HORIZONTAL COLLABORATION IN ROAD FREIGHT TRANSPORT: A METHODOLOGICAL APPROACH

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1. Introduction

Road freight transport plays a crucial role in supporting the UK economy, accounting for 79% of all domestic freight movements (Department for Transport UK, 2022). However, there are inefficiencies in road freight operations, with 30% of vehicles running empty and only 63% of vehicles loaded to their capacity during their journeys (Department for Transport UK, 2022). These inefficiencies not only impact operating costs but also contribute to higher carbon emissions. According to the Department for Transport UK (2022), transport is the largest GHG emission sector contributing 24% of the overall carbon emissions in the UK. Governments are setting decarbonisation targets to reduce carbon emissions from their economy and in the UK, the government has announced a plan to reduce carbon emissions to net-zero by 2050. All sectors including transport will need to deliver substantial emission reductions to achieve net-zero targets. If no decarbonisation solutions are implemented in the near future, it is expected that this percentage of carbon emissions will keep increasing. This can be partly explained by the increasing consumer demand for road freight transport operations as the economy grows and consumer habits change. Verdonck et al. (2016) highlight that most companies primarily rely on internal measures to enhance efficiency from transport operations, but they have exhausted opportunities for further process optimisation within their existing operational boundaries.

Horizontal collaboration is one of the solutions that go beyond organisational boundaries and has the potential to provide efficiency improvements, such as carbon and cost savings between 10–30% (Cruijssen, 2014). There are many logistics strategies that can be implemented within horizontal collaboration in the road freight transport sector to achieve efficiency improvements. This includes co-loading of part loads, consolidation of loads, use of consolidation centres and backhaul strategies (Palmer et al., 2018). This paper focuses on the backhauling strategy of road freight transport operations, as highlighted by McKinnon and Ge (2006), where the empty running of backhauls is recognised as a wasted opportunity, resulting in both economic and environmental inefficiencies. Compared to other logistics strategies, backhauling strategy is operationally a straightforward strategy to implement, where fixed costs and operational complexities are low. This study proposes a novel methodology to analyse backhauling strategy based on horizontal collaboration, with the objective of minimising empty running and maximising vehicle utilisation in road freight transport movements, thereby reducing both cost and carbon emissions.

2. Literature Review

2.1 Types of Collaboration

The aim of backhaul is to minimise empty running by ensuring that transport vehicles return from a delivery trip with a load, thereby reducing inefficiencies. This strategy can be implemented using collaboration. Collaboration can be classified into two types: vertical and horizontal. The literature is rich in vertical collaboration and this form of collaboration is common in supply chain management and logistics where retailers collaborate with their

suppliers, logistics service providers and customers to create a win-win situation (Fugate et al., 2009; Hingley et al., 2011). It aims to integrate supply chain members at different levels of the supply chain to improve the efficiency of logistics operations and reduce costs by sharing information, resources and responsibilities. This collaboration is widely implemented by organisations in the UK's fast moving consumer goods (FMCG) sector where retailers control suppliers for frequent deliveries and adhere to strict delivery time windows to improve their transport operations (McKinnon and Ge, 2006; Dadhich et al., 2016). In vertically collaborated supply chains, retailer's implement a strategy known as factory gate pricing

(FGP) that improves backhauling and managing backhauls (Fernie and Sparks, 2014; Potter et al., 2016; Mason et al., 2007). FGP is a pricing strategy where transport costs shift from the supplier to the buyer at the factory gate or production facility. In this case leading retailers practice vertical collaboration with suppliers and instead of returning empty to a distribution centre (DC), these vehicles can be directed to supplier locations to collect orders and transport them to the retailer's DC (Mason et al., 2007). This is a common practice that allows reduction in vehicle kilometres, driving time and number of vehicles used.

The second form of collaboration, known as horizontal collaboration, has gained more attention in recent years (Crujssen et al., 2007; Verdonck et al., 2016; Pan et al., 2019). This type of collaboration is less common in UK road freight transport operations. It can be defined as 'bundling transport of companies operating on the same level of the supply chain, who have similar or complementary transportation needs' (Vanovermeire et al., 2014). The main advantages of horizontal collaboration include increased costs savings and productivity, carbon emission reduction, customer service, asset utilisation and market position. According to Ferrell et al. (2020), the elimination of empty backhauls constitutes a fundamental approach through which horizontal collaboration can enhance operational efficiency. In horizontal collaboration, backhauling is implemented through organisations operating at the same level within the logistics network and often involves competitors who transport goods along similar routes to their customers. One of the classic real-world case studies includes Nestlé and United Biscuits, two competitors in the food market, who have implemented a collaborative system to enhance their respective logistics operations. This involved coordinating the collection of each other's loads following the completion of their own delivery requests. As a result of implementing this backhauling strategy, the companies were able to reduce empty running from 22% to 13% within a span of four years (Transport Research Laboratory, 2017).

2.2 Methodologies to Solving the Backhauling Strategy

The Vehicle Routing Problem (VRP) involves the task of determining a set of vehicle routes where (1) each customer is served by a single vehicle, (2) all transport routes begin and end at the same depot, (3) the total demand on each route does not exceed the vehicle's capacity, and (4) the overall distribution cost is minimised. The VRP has various versions that take into account practical considerations based on specific conditions and characteristics of the problem. This includes capacitated VRP, stochastic VRP, periodic VRP, split-delivery VRP, multi-depot VRP, pick-up and delivery VRP, time window VRP, and backhauls VRP (Gansterer and Hartl, 2018; Toth and Vigo, 2014). The Vehicle Routing Problem with Backhauls (VRPB) involves the classification of clients into two categories: (i) Linehaul customers, who require product deliveries, and (ii) Backhaul customers, for whom product pickups are required, usually situated along the return route of vehicles that have made deliveries to linehaul customers (Santos et al., 2020). In essence, linehaul customers receive deliveries, while backhaul customers provide pick-up points to collect goods for the return trip. In the VRPB, a priority condition is established between these two client groups, meaning that the linehaul customers must be served before the backhaul customers on each route. Many studies have focussed on solving the VRPB using exact and heuristics algorithms (Pradenas et al., 2013; Toth and Vigo, 2014; Koç and Laporte, 2018)."

Using heuristics provides a practical and flexible approach to solving complex logistics problems compared to exact solutions, as heuristics offer a more efficient and effective approach to solving network problems while still providing satisfactory solutions. An heuristic approach therefore offers a "good enough" solution that allows for baseline understanding and adaptation to different situations and changing assumptions. Previous heuristics developed for the VRPB have proven valuable in establishing new road freight transport networks specially in real-world routing problems (Toth and Vigo, 2014). Therefore, as this study focuses on using existing routes from origin to destination, heuristics such as the insertion heuristic and nearest neighbour become appropriate choices (Koç and Laporte, 2018). These heuristics optimise the backhaul problem by making minor modifications to the current routing and considering distances between depots and customers, resulting in improved fleet utilisation with minimal operational changes. These heuristics match their specific constraints, in particular delivery time windows, to gain insights into how backhauls can enhance their current operations. Previous studies in horizontal collaboration using backhaul focussed on the problem from a strategic level, while not considering operational constraints, such as delivery time windows (Palmer et al., 2018; Palmer et al., 2016).

3. Methodology

3.1 Problem Description

The problem is similar to the collaborative pickup-delivery strategy where customers of one participant are served by vehicles

of the other participant in backhauls (Santos et al., 2020). Collaborative pickup-delivery is the most implemented strategy in collaboration and tends to be independent of the objective function used and type of network. As shown in Figure 1, the transport network is composed of depots of two companies stated as origin and return depots, a set of linehaul customers (represented as A to E) and set of backhaul customers (represented as P, M and Y). The fleet of homogeneous vehicles of the company are located at their depots.

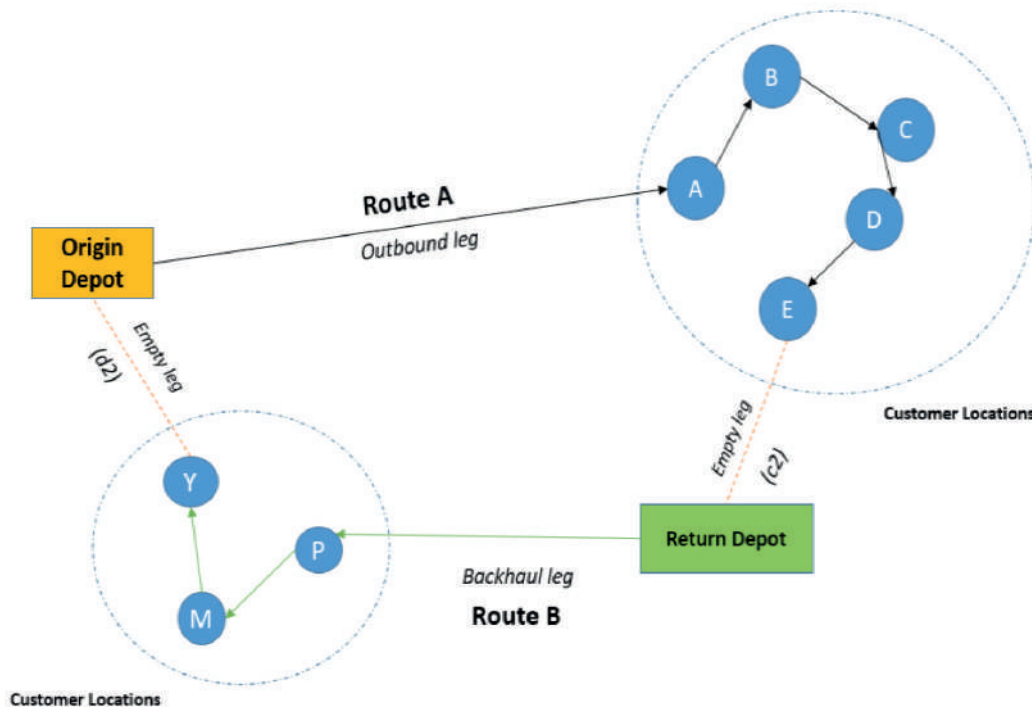


Figure 1: An illustration of the collaborative pickup-delivery strategy.

The backhauling algorithm starts once deliveries from the origin depot to their customers have been completed, at which point it initiates the search for the nearest depots. When the nearest depot is located in close proximity, If delivery and vehicle constraints are satisfied, the load is assigned to the vehicle that serves the customers of the return depot on the return route to the origin depot. This is illustrated in Figure 1, where a vehicle from the origin depot delivers goods to customers along Route A during the outbound leg. After completing the customer deliveries from A to E, it proceeds to find the nearest return depots from customer E. If operational constraints like delivery dates, delivery time windows, vehicle capacity and proximity to the depot allows for backhaul deliveries, the algorithm merges these routes into backhaul journeys. In this specific scenario, the vehicle operates an empty leg and searches for a return depot. Once a return depot is located, it delivers goods to customers P, M and Y along its return path to the origin depot.

3.2 Proposed Algorithm and Case Study

The proposed algorithm for backhauling described in Figure 2, represents an extended version to an agent-based model by Utomo et al. (2021) that uses heuristics for vehicle routing. It includes the following steps:

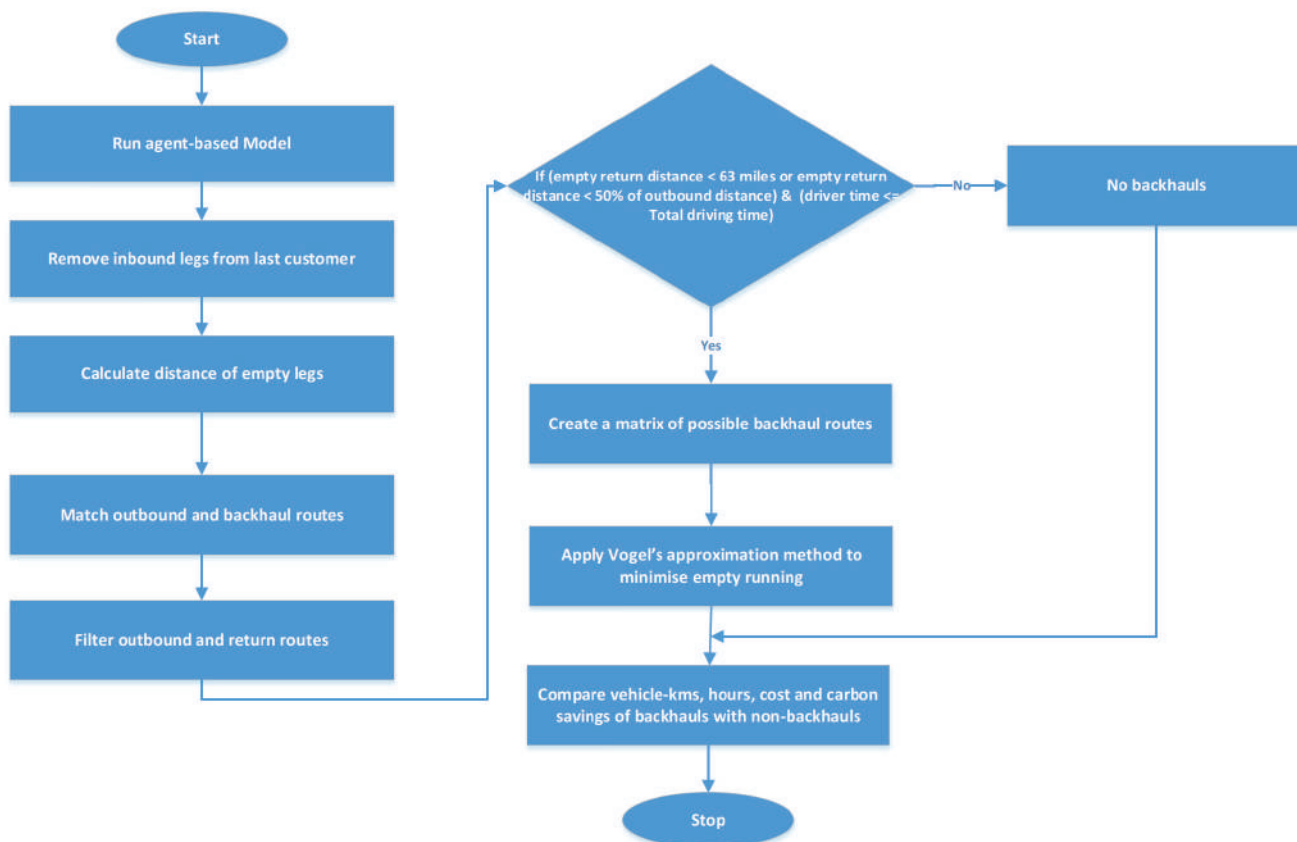


Figure 2: The proposed backhauling algorithm.

The proposed backhaul algorithm was applied to a case study with three FMCG companies and each of the steps within the algorithm is explained at the hand of the case study.

1. Run agent-based modelling (ABM) model: ABM is a method that describes complex system with heterogeneous components and derive insights on their emerging behaviour and properties (Nilsson and Darley, 2006). It provides a simulation-based environment for organisations to test the impact of many interactions between agents in a virtual world. This approach provides an inexpensive way of simulating and testing logistics strategies in road freight transport. The ABM model used in this algorithm is inherited from an urban delivery project in the Centre for Sustainable Road Freight (Utomo et al., 2021). This model was primarily designed for home deliveries, however, fundamental methodology for heuristic algorithms in agent-based models remains consistent for both urban and long-haul delivery models. As a result, the existing parameters for urban delivery models were expanded to incorporate a broad range of deliveries in particular long-haul and regional deliveries. The model consists of three types of agents: the company agent, the depot agents (a population of agents), and the vehicle agents (a population of vehicles). The company agent plays a critical role in the model as it selects depots to serve its customers using specific vehicles and using data provided by the companies involved. The distance calculations between various points are performed using the OpenStreetMap road network dataset, which utilises Dijkstra's Shortest Path algorithm to determine the distances. The next step in the simulation involves allocating the generated orders to multiple vehicle journeys. To optimise this allocation process, a modified version of the nearest neighbor heuristic is used, taking into account the punctuality of the delivery (Utomo et al., 2021). This means that it may be more practical to assign a vehicle that is farther away from the customer's location but can deliver the orders within the specified time window, rather than assigning the closest vehicle that would fail to meet the delivery time requirements. The ABM model was run to read all orders and generate routes for data provided by companies.

Data were provided by the three FMCG companies for a month in April in 2019 and included all freight transport flows between depots, suppliers and customers. The data comprised of origin and destination postcodes, quantities moved (in

pallets and roll cages), delivery date, delivery time windows and the vehicles with carrying capacity and storage type. The results from this model provides total vehicle kilometres (kms), driving hours, number of vehicles and sequence of routes. The fixed and variable costs of transport deliveries were derived from the Road Haulage Association cost tables (RHA, 2019). Also, carbon emission conversion factors were derived from Department for Business, Energy and Industrial Strategy using activity-based carbon reporting approach (DBEIS, 2020).

The ABM model was designed to deliver to all customers in the UK mainland only and incorporated several assumptions regarding parameter values to simulate the logistics operations accurately:

- a) *Analysis of data timeline:* The model focused on data from April 2019, and the simulation was designed to run over a one-month period. The dates were converted as numbers from 1 to 30 representing the days within one month in the model.
- b) *Average vehicle speed:* An average vehicle speed of 60 km/hr was considered. This speed assumption accounts for factors such as long-haul and regional deliveries as well as potential traffic congestion.
- c) *Driving duration in one day:* The model assumed a total driving duration of 20 hours in a single day. This includes two shifts of 9 hours each for drivers, along with an additional 2 hours to complete a small proportion of journeys within the model's timeframe.
- d) *Break duration of drivers:* Drivers were allocated a 30-minute break after every 5 hours of driving, adhering to standard driver regulations.
- e) *Loading time at the depot:* The model assumed a loading time of 45 minutes at the depot. This parameter represents the time required for loading goods onto the vehicles before departure.
- f) *Unloading time at customer's location or destination:* The unloading process at the customer's location was divided into fixed and variable time components. The fixed time was set at 10 minutes, while the variable time was calculated at a rate of 4 minutes per pallet footprint with a maximum limit of 60 minutes per customer for unloading.
- g) *Vehicle types and capacity:* A homogeneous fleet of vehicles consisting of 44-tonne artic vehicles was allocated to all depots. This means that all depots within the simulation used the same type of vehicles with a load capacity of 44 tonnes. This assumption ensures consistency and simplifies the modelling process by assuming uniformity in the vehicle fleet across all depots.
- h) *Standardisation of load:* To ensure consistency and comparability, all data within the model was converted to a standardised 26 pallet footprint. This conversion allowed for a uniform representation of goods across different scenarios and calculations."

2. Remove inbound return legs: In the second step, the inbound return leg of the routes was removed, and the total vehicle-kms, driving hours, cost, and emissions were recalculated. The aforementioned process was repeated for all secondary movements from depot to customers, resulting in comprehensive data collection.

3. Calculate distance of empty legs: If backhaul routes were deemed acceptable based on delivery date, driving hours and delivery time windows, the total vehicle-kms, driving hours, cost, and carbon emissions for the combined routes were recorded. Additionally, the distance of the empty leg was calculated from the last customer to all available depots using GIS locations. This distance is calculated using the Haversine function with a wiggle factor of 1.2 multiplied to Haversine formula to reflect close to real distance in the UK geography. This information was stored in a matrix corresponding to the routes for both the linehaul route (Route A) and the backhaul route (Route B) as illustrated in the example in Figure 1. The same process was applied to all subsequent routes while keeping the first route constant.

4. Match outbound and backhaul routes: A combination of all eligible outbound and return routes were matched.

5. Filter matched outbound and return routes: The combined routes were filtered based on order delivery date, order delivery times, and total driving time. Also, the return distance should be less than 63 miles or empty distance should be less than 50% of outbound distance (McKinnon and Ge, 2006). If the combination of routes did not match these criteria, those routes were excluded. After completing all matches, the second route was compared against all subsequent routes, following the procedure described from Step 1.

6. Create a matrix of possible backhaul routes: Upon completion, a matrix was created containing all possible matched backhauls. The acceptable return loads were recorded in the matrix designed using Python. Acceptable return loads distances were recorded in a matrix and the routes that were not compatible were filled with a very large number to deem it infeasible. This is to ensure that those routes are never selected during the next stage where Vogel's approximation method is applied.

7. Apply Vogel's approximation method (VAM): The objective of the analysis was to minimise empty running in the matrix of all possible backhaul routes. VAM was utilised in the process as it follows a systematic approach that involves comparing the penalties associated with the differences between the two lowest costs in each row and column. The row or column with the highest penalty is selected, and the allocation is made to the cell with the lowest cost within that particular row or column. This process is repeated until all the supply and demand values are exhausted or allocated. The experimentation begins by creating a cost matrix, which represents the transportation costs from sources (supply) to destinations (demand). Supply and demand values are entered as 0.405 instead of 1 to improve on accuracy. Next, the method identifies the difference between the two lowest costs in each row and column. These differences are referred to as penalties and serve as indicators of the potential for cost savings.

The row or column with the highest penalty is selected for allocation. The allocation process involves finding the cell with the lowest cost within the chosen row or column and assigning the maximum feasible quantity to that cell. The supply and demand values are then adjusted accordingly. This step is repeated until all the supply and demand values are fully allocated. VAM offers a simpler way of executing the transportation method steps."

However, it is important to note that applying VAM to an unbalanced transportation problem does not guarantee an optimal solution (Chacko et al., 2017). In such cases, VAM often allocates items to dummy cells before considering other cells in the table, as highlighted by Balakrishnan (1990). Consequently, the initial solution obtained may not be highly efficient for unbalanced problems. Still, the VAM typically yields a satisfactory solution that requires comparatively less effort and it's widely used in the vehicle routing problem. In this study, VAM was implemented to determine the most cost-effective backhaul options from the available alternatives.

8. Compare non-backhaul with backhaul routes: The routes with both backhauls and non- backhauls were considered to obtain the total vehicle-kms, driving hours, cost, and emissions. These values were then compared with the totals from the original non- backhaul routes recorded in Step 1.

4. Conclusion

A novel methodology to analyse the backhauling strategy in horizontal collaboration is proposed in addressing the research gap relating to operationalisation of backhauling strategy in horizontal collaboration. Although previous studies addressed this issue at a strategic level (Palmer et al., 2018; Palmer et al., 2016), this study further includes the relevance of operational constraints, such as delivery time windows, when matching backhaul routes in the context of horizontal collaboration. Improving backhaul operations through this proposed methodology may assist companies in making more efficient use of their resources and reduce vehicle kilometres thereby reducing operational costs, resulting in higher profitability and reduction in carbon emissions.

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THE SUPPLY CHAIN RISK MANAGEMENT OF CROSS-BORDER E-COMMERCE

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1. Introduction

The improvement and widespread adoption of information technology have provided the conditions for the development of cross-border e-commerce (CBeC). CBeC is becoming one of the mainstream shopping methods in many countries and regions (He et al., 2022).

Compared with the domestic e-commerce, CBeC has a more complex supply chain, less stable supply-demand relationships, and greater challenges in controlling logistics, information, and financial flow (Zhou et al., 2022). Any disruption generated at any node from the supply chain will propagate and amplify along the supply chain, leading to significant impacts (Berger et al., 2023).

The review of past research shows that most articles on CBeC supply chain risk management (SCRM) focus on a single dimension and lack discussion of the relationship between risks, while the lack of systematic identification and management of risks hinders the development of the industry (Zhu et al., 2023). Therefore, the purpose of this paper is to establish a SCRM framework applicable to CBeC to solve the problem of how to systematically identify and classify CBeC risks and how to manage risks in multiple dimensions.

This is the first attempt to classify the known risks of CBeC from three dimensions of characteristics, location and impact by establishing the connection between CBeC supply chain risks (SCRs) and SCRM. CBeC can obtain a systematic SCRM strategy by examining the risks from multi-dimensional.

This paper will first provide an overview of SCRM, CBeC and CBeC SCRs; Then introduce the method of literature review; Next, we develop a conceptual framework to cover the main points; Finally, we summarize the research and propose the advice for future research.

2. Literature Review

2.1. Supply Chain Risk Management

The definition of SCRM is using quantitative or qualitative methods to identify, assess, treat and monitor the risks that will have a negative impact on the supply chain from the macro or micro level (Ho et al., 2015).

Effective SCRM is based on the accurate identification and classification of primary risks and secondary risks. For typical SCRs, risks can be divided into endogenous risks and exogenous risks, or internal risks, external risks and network related risks (Peck, 2005; Ritchie & Brindley, 2000). Based on the type or impact of risk, risk can be categorized into operational risk (supply and demand risk) and disruption risk (Craighead et al., 2007; Tang, 2006). From the perspective of supply and demand, risks can be further classified into supply risk, production process risk, demand risk and external risk (Samvedi et al., 2013).

On this basis, Wicaksana et al. (2022) propose an SCRM classification method that summarizes and integrates the previous SCR classification methods according to the characteristics of risks (internal/external, intentional/unintentional), location of risks (supply, demand, production) and the impact of risks (environmental, social and economic).

2.2 CBeC Supply Chain

CBeC refers to enterprises offering products to overseas consumers through digital channels such as proprietary sales websites or online sales platforms. (Giuffrida et al., 2017). As shown in Figure 1, CBeC supply chain can be divided into

domestic, transport and overseas. By effectively managing logistics, information flow, and financial flow, CBeC is able to enhance its supply chain service capabilities and establish competitive advantages (Liu et al., 2021; Wang et al., 2020).

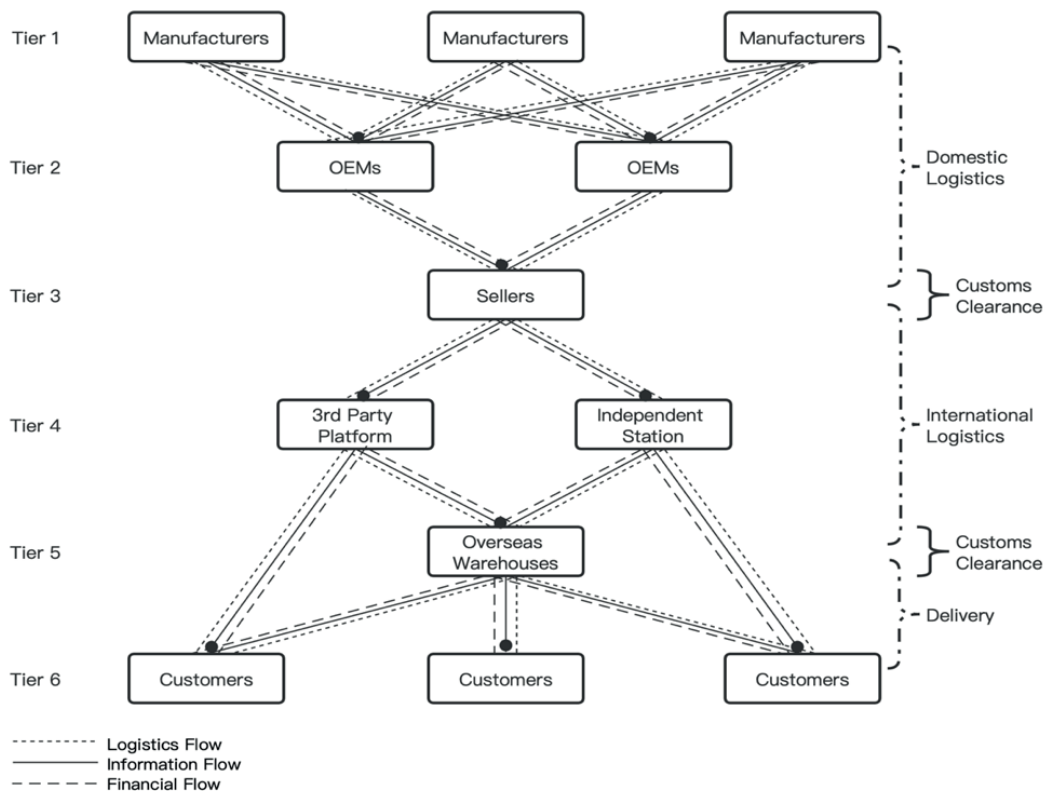


Figure 1: CBeC Supply Chain
(Source: Fang and Wang 2021)

2.3 CBeC SCRs

The risks in CBeC supply chains mainly revolve around three aspects: transactions, consumers, and supply. From the perspective of transactions, the risks include payment risks, chargeback fraud risks, and credit risks (Ma et al., 2018); From the perspective of consumers, perceived risk comes from duty risk, forfeiture risk, delivery risk, financial risk and privacy risk (Li et al., 2019; San Martín et al., 2011); From the perspective of supply, customs clearance risk, logistics risk are the important factors leading to supply chain disruption (Giuffrida et al., 2020). As shown in Figure 1, CBeC supply chain has a large number of participants, and the risks generated at each node will spread along the supply chain and affect other participants (Fang & Wang, 2021; Zhu & Zhou, 2020). However, the existing research on CBeC SCRM lacks the systematic classification of risks and the discussion of the relationship among risks, which limits the formation of a general risk management framework.

3. Research Methodology

Due to the limited research on CBeC SCRM, in order to collect as much CBeC SCRs as possible, we use “cross-border e-commerce”, “supply chain risk management” and their synonyms as keywords to search articles published between 2010 and 2022 on Scopus and Abi/inform. After reviewing the abstract of the searching results, 125 articles not related to CBeC were excluded. Among the remaining 24 articles, 12 are related to risk management or supply chain risk management, and 12 are related to operation management or supply chain management.

4. Findings

4.1. The Systemic Classification of CBeC SCRs

After conducting the literature review, we identified 42 CBeC SCRs including 29 primary risks and 13 secondary risks. Furthermore, based on the classification approach proposed by Wicaksana et al. (2022), these risks were reclassified and further refined along three dimensions: characteristics, location, and impact (as shown in Table 1).

	Level 1	Level 2	Level 3
Characteristics of risks	Exogenous	Environmental risks	Natural environmental risk; Economic environmental risk; International business environmental risk; Industrial policy environmental risk; Invalidation of government agencies; Cultural risk
		Political risk	Risk of laws and regulations
		International logistics interruption risk	
	Endogenous	Logistics risk	Logistics timeliness risk; Logistics information risk
		Procurement risk	Product quality risk; Defective products risk; Product delivery risk; Intellectual property disputes risk
		Manage operational risk	Human resource risk
	Intentional	Information fraud	
	Unintentional	Manage operational risk	
Location of risks	Supply-side	Supplier risk	Product quality risk; Defective products risk; Product delivery risk; Intellectual property disputes risk
	Manufacturing-side	Industrial chain risk	
	Demand side	Consume perceive risks	Cost performance / Financial risk; Distribution logistics; Customer service/service supply chain risk; Product quality / authenticity / shelf-life risk; Privacy risk; Customer duties risk; Confiscation risk
	Flow of money	Cross-border transaction risk	Online payment risk; Credit risk; Information risk (risk of data acquisition failure risk); Capital settlement risk
	Flow of goods	Infrastructure risk	
		Logistics risk	
	Flows of information	Risk of data acquisition failure	
Impact of risks	Economic impact	Economic loss	
	Social impact	Working conditions	
		Company ethics	
		Unfair treatment	
	Environmental impact	Waste issues	
		Environmental-related scandals	

Table 1: Classification of CBeC Supply Chain Risks

(Source: Li et al., 2019; Fang and Wang, 2021; Ma et al., 2018; Giuffrida et al., 2020)

4.2 CBeC SCRM conceptual framework

On the basis of reclassifying the CBeC SCRs and integrating them with the SCRM process (identification, assessment, treatment, monitoring), we developed a multi-dimensional SCRM framework (as shown in Figure 2). In the first stage, risky events are put into the risk identification system, and the inherent risks of the supply chain from three dimensions (characteristics, location, impact) can be identified. Then the impact pathway of risks on the triple bottom line (economic, social, and environmental) can be further identified from top to bottom.

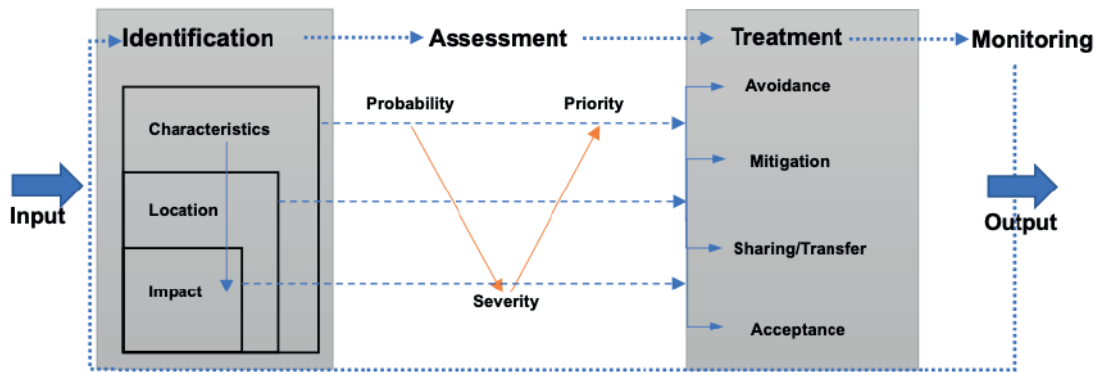


Figure 2: CBeC SCRM Framework

In the second stage, risks can be assessed by using different tools according to the identification of risks. The probability and severity of risk can determine the priority of risk treatment.

On the basis of risk assessment, the consequence of the risk can be reduced by implementing acceptance, avoidance, sharing/transfer or mitigation strategies (Aqlan & Lam, 2015). Different treatment methods can be adopted according to the nature of risks in different dimensions.

Risk management is a dynamic process, so the above steps need to be continuously monitored and adjusted accordingly, and the data generated during the process should be recorded to provide the basis for future risk management (Fan & Stevenson, 2018).

5. Conclusion and Future Research Direction

This study built a multi-dimensional SCRM framework which has practical implications. CBeC merchants can define risks and their relationships from multi-dimensional and then obtain a SCRM combination to establish competitive advantages and achieve long-term survival.

There are limitations of this research. First, this is a conceptual framework which may overlook the complex situation of CBeC, so empirical research is needed to prove its effectiveness. Secondly, the research focuses more on risk identification and lacks methods for risk assessment and treatment, which can be a future research direction.

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THE HUMANITARIAN SUPPLY NETWORK: A PARADIGM PROBLEM AND A BIG IDEA

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Introduction

This research examines whether greater effectiveness and efficiency in humanitarian supply chains can be achieved by adopting a cybernetic approach to information flow. It looks at how, by taking a holistic view of humanitarian supply operations, the issues that arise due to the complexity in humanitarian supply networks can be resolved systematically. It also considers how individual organisations' supply chains exist within a complex logistic network and how decision-making in one stakeholder organisation can have major, but unintended effects on other stakeholders. Such conflicts can arise as a result of marked differences in stakeholders' aims, ethos and attitude towards resources. Only by taking a holistic approach to examine the humanitarian supply network can the information which flows vertically through the hierarchical structures of stakeholder organisations and horizontally between stakeholders be fully understood. Little if any research appears to have been conducted into humanitarian supply networks using a holistic thinking approach as its theoretical base, despite the Nassimbeni and Sivadasari, et al contribution in New and Westbrook (2005) suggesting a strong correlation between supply chains and Systems Thinking.

Eriksson and Karlsson (2017) and Raillini, et al (2020) capture the complexity of humanitarian supply chains and posit that commercial supply chain management theoretical models have been unsuccessful in resolving humanitarian supply chain issues. There is currently no single framework that captures a humanitarian supply network holistically, and as a result, a theoretical gap exists. This research takes a cybernetic approach to modelling the paradigm to provide a theoretical mechanism for resolving issues. It is recognised that friction between stakeholders is inevitable in such an unstable, often austere, and yet dynamic environment, and that the nature of the stakeholders renders the concept of an overarching governance entity difficult. Therefore, to achieve better cohesion through a cybernetic concept, the system would have to be autopoietic: mutually owned, mutually beneficial and effectively self-maintaining and self-policing. This paper forms part of a doctoral research project which explores how autopoietic cybernetics can contribute to humanitarian supply network operations.

Research Methodology

The research focuses on the human activities that facilitate decision-making and the flow of information and supplies during a large-scale disaster response operation. The humanitarian supply chain paradigm is a social construct where organisations and individuals interact in a politically social manner, so ontologically, taking a Social Constructionist perspective is highly appropriate. Actors' behaviours and perceptions of coordination, cooperation and collaboration are influenced both by local conditions and organisational business practices. They find themselves operating in atypical, unstable and austere situations where human emotion, instinctive reaction and risk-taking outside the individual's normal parameters are commonplace. The epistemology of this research is subjectivist to make sense of actors' behaviours and decisions and is guided by the work of Beech (2005) in terms of charting a route from the subjective ontology of the study, through an interpretivist research epistemology, to an inductive methodology and resulting study techniques. The established logic of the Research Onion by Saunders, et al (2016), was used to bound the available techniques within a multi-method qualitative narrative.

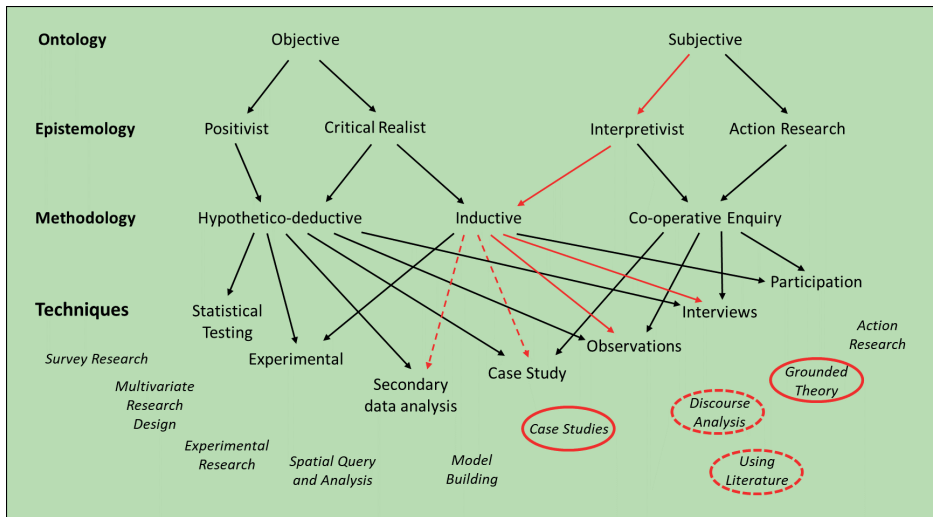


Figure 1. Research Strategic Routes. (Adapted from Beech, 2005).

The research was conducted as a three-stage process. Stage 1 comprised the preparation work which ensured the design was coherent and focused on the aims and objectives of the doctoral project, the gaps in knowledge as revealed in the associated literature review and the theoretical considerations involved in taking a holistic approach to the problems and challenges that have been shown to exist in the literature.

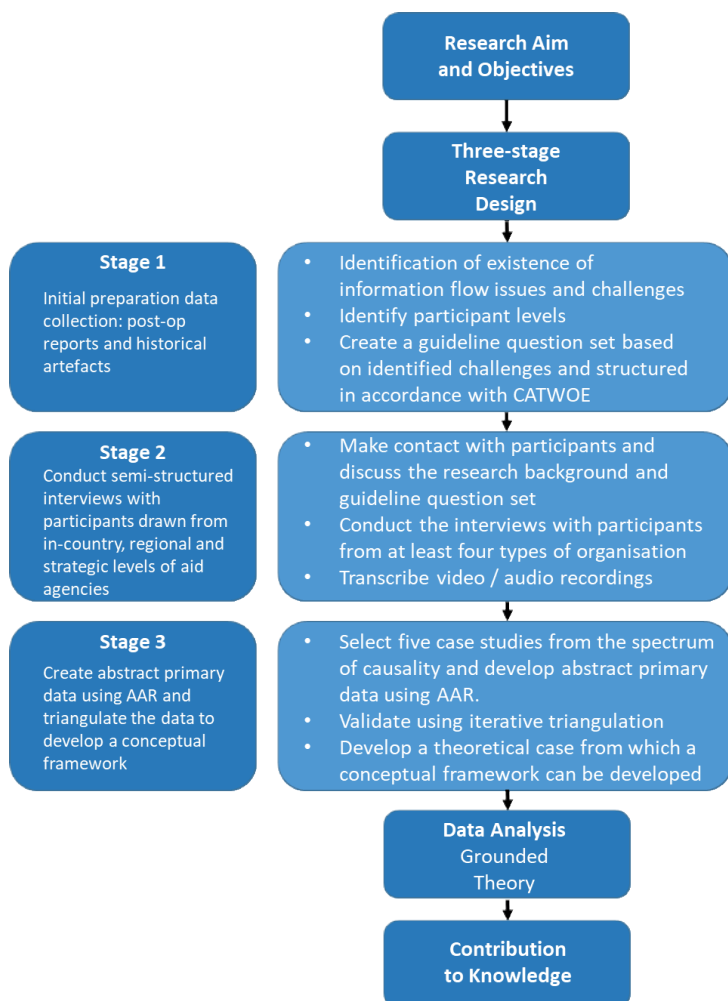


Figure 2. Three-stage Research Design.

Stage 2 involved the collection of qualitative primary data by conducting semi-structured interviews with relevant participants determined by a participation identification exercise. Aid organisations were divided into four categories from which individuals were selected:

- UN Agencies – such as UNICEF and WFP;
- INGOs – such as CRS, HELP Logistics, OXFAM;
- IGOs – such as USAID and the UK's FCDO;
- The Global Logistic Cluster – a (non-political) component of WFP.

Within the four categories, individuals working at the strategic, regional and in-country levels of operation were identified. IGOs do not tend to maintain an ongoing in-country presence, but rather contract commercial 3PL / 4PL and not-for-profit companies to conduct in-country business on their behalf and in accordance with tightly controlled budget-focused contracts.

The devised question set, while focused on the research objectives, acted as a handrail for the researcher rather than a strict script, thereby allowing respondents to raise topics which may not have come to light during the literature review. This guideline question set was sent to potential participants to allow them to orientate themselves to the essence of the research and give them an opportunity to take a level of stakeholder ownership in the research. This was done to increase the likelihood of the individual agreeing to participate, as it would confirm to them that their contribution lay within their sphere of knowledge.

Stage 3 was the derivation of 'abstract primary data' drawn from case studies taken from across the humanitarian spectrum of causality through a meta-synthesis process. Empirical case studies secondary data, independent reports and evaluations of past operations, 'known-knowns' and researcher intuition were used to interpolate the most likely reason for a known end state. Five case studies, drawn from different types of operation on the disaster spectrum of causality, were analysed (see Fig. 3). Abstract reasoning allowed a most-likely case scenario to be constructed from the known outcomes, thereby creating a set of 'abstract primary data': data to underpin the most likely case scenario.

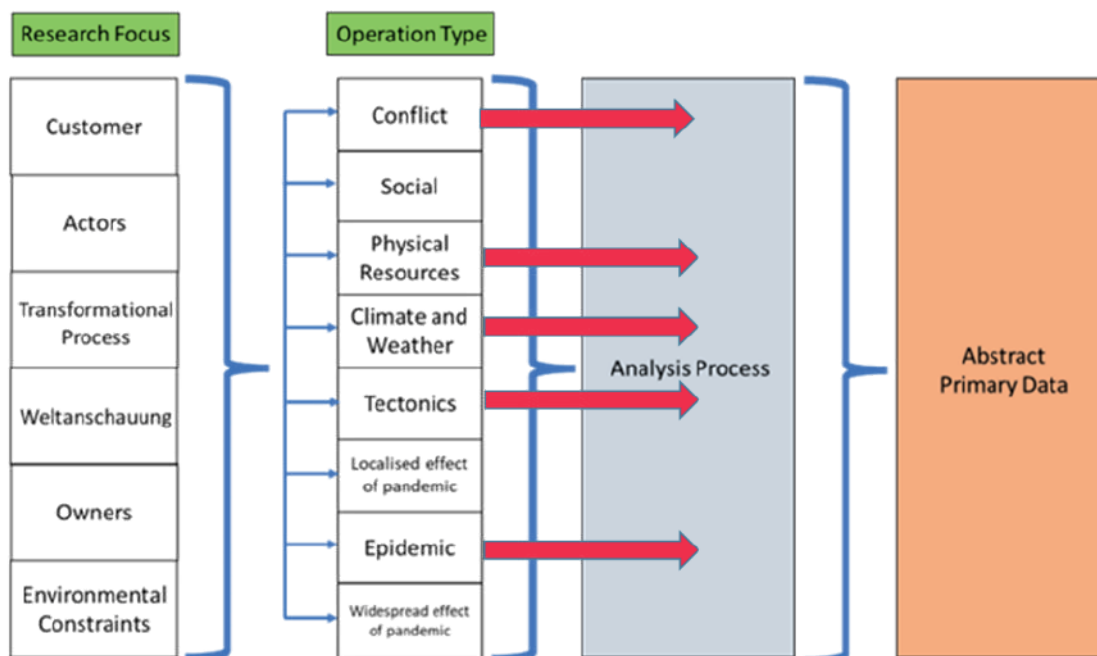


Figure 3. Applied Abstract Reasoning.

Before the derived data was accepted for analysis, it was checked against the known end states to ensure that the logic used in the abstraction process was robust. This new data was then further critiqued using iterative triangulation. The process of logical reasoning is also underpinned by the existing literature and the primary data gleaned from the interviews.

Process of Analysis

The two distinctly different data collection methods required different analytical strategies to derive meaning. The interview data came from individuals who had either worked at different levels within their organisation or had worked for several different types of organisation. This provided added richness to the data because a single interviewee could provide more than one testament and could provide comparisons that would be otherwise difficult to access. Grounded theory was the analytical tool selected because of the manner in which the researcher must interact with the data. Charmaz (2014) describes grounded theory '[beginning] with inductive data, invokes iterative strategies of going back and forth between data and analysis, uses comparative methods and keeps you interacting and involved with your data and emerging analysis' (p.1). The iterative nature is achieved by reflecting on the raw data and the data derived from thematic examination, comparing data from and at the different process stages, and confirming relevant and meaningful further coding and analysis leading to the creation of substantive theory based on theoretical sampling themes.

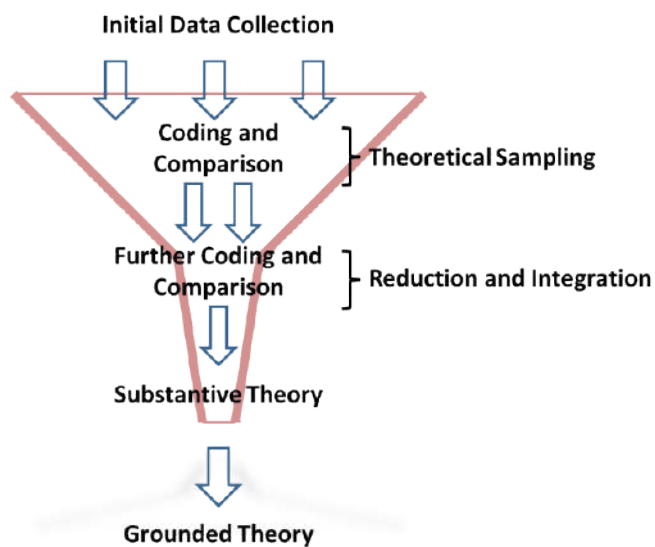


Figure 4. Funnel Structure of the Grounded Theory Approach. (Adapted from Charmaz, 2014).

These strands of substantive theory can legitimately stand alone, pursuant to issues arising from specific aspects of humanitarian network operations but they can also be combined to create grounded theory which gives meaning to the humanitarian supply network as a whole. Charmaz (2014) refers to the form of grounded theory analysis that uses a process of coding, reflection and theoretical sampling as 'constructivist grounded theory', in that each stage of the process takes account of qualitative enquiry across all the interviews conducted. She concludes that 'constructivist grounded theorists aim for abstract understanding of studied life and view analyses as located in time, place and situation of the inquiry' (p.342).

To provide the necessary academic rigour to corroborate the findings of the interviews, academically robust secondary data was required. Abstract reasoning allows a most-likely case scenario to be constructed, thereby creating the set of abstract primary data mentioned above. Five abstract reasoning cases were selected from across the spectrum of causality encapsulating conflict, physical resources, climate and weather, tectonics and epidemic. Each case considered an aspect of the logistics operation for which there is little or no explanation, and for which the decision-making process needed to be traced back from the end result using available secondary data and practitioner intuition. A specific issue was identified, and the decision options were considered and analysed before a conclusion was drawn through applied abstract reasoning.

The first four case studies refer to international emergency response operations directly linked to a type of disaster shown in Fig.3:

- A supply chain management issue caused by changing from a Push to a Pull logistic strategy mid-way through the 2015 Ebola pandemic in Sierra Leone.
- Supply chain management issues experienced in the aftermath of Cyclone Eloise, Mozambique in 2019.
- Access and border-crossing issues arising from government controls following the 2015 Nepal earthquake.
- Issues with essential supplies during the ongoing conflict in Yemen during 2019.

There are few examples of physical resource-based disasters which have attracted international responses: most tend to be resolved by national governments, e.g. the 1986 Chernobyl disaster in the former USSR. For this reason, the physical resource-based issue considered in the fifth case study is a resource failure during an ongoing emergency response operation, namely gross inefficiency in the customs clearance of aid relief consignments in Sierra Leone during the Ebola crisis, one which exacerbated an already chaotic situation. The data derived from the applied abstract reasoning meta-synthesis process was analysed using documentary narrative analysis techniques, and together with the substantive and grounded theory outputs from the grounded theory process, was subjected to a triangulation process using iterative triangulation (Lewis, 1998). This process was used to construct a theoretical case from which a conceptual framework could be validated for its feasibility, but not its utility and usability as described by Platts, et al (1998). The use of a theoretical case is not a typical research approach, but neither is it new. Prior to the existence of primary data relating specifically to the effects of demand fluctuations in a retail and wholesale supply chain, Forrester (1958) created a theoretical case for use in his Beer Distribution Game, based on secondary data which he knew to be factual in the context of supply chain retail demand. Following the same logic and principles, this research uses a hypothetical humanitarian operation scenario which focuses on the flow of information along and between humanitarian supply chains. It demonstrates that the humanitarian supply chain domain is complex, interconnected, and takes the form of a network of individual supply chains coordinated through the global cluster system.

Research Findings

Transcripts of the interviews were reviewed, and open codes were identified, including aspects of supply chain and network ownership and control, the role and effectiveness of the Global Logistics Cluster, the appetite and perceptions of stakeholder interaction. By matching these open codes to the contexts described by the interviewees, axial themes emerged which were cross-referenced with the transcripts before being given an axial code. Focused coding, analysis and further coding led to theoretical sampling, further reflection and comparison. A process of reduction and integration was used to produce a substantive theory for the reduction and integration groupings, of which there were seven. Bringing these seven strings of substantive theory together produced a grounded theory statement:

Within the humanitarian supply network, no owner / governance entity exists, and organisational sensitivities preclude the Global Logistic Cluster from extending its mandate into the control of supply chains. Whilst there is a willingness to share information, there is no mechanism to achieve a network of information that takes the holistic picture into consideration. The structure of a deployed Log Cluster could be developed to formally involve other stakeholders in 'office-bearing' functions, but much scepticism exists regarding this even though such an initiative would promote closer organisational engagement at the HQ / strategic level. There is a willingness to work together, but again, there is no mechanism. If such a mechanism were to be developed, it would have to be autopoietic in nature where decision-making influences and control measures would be organic to the structure so as to allow stakeholders to maintain their unique identities and cultures. To take the steps to work truly collaboratively, organisational governance and the operational environment would have as much a role to play as logistic functions. Where issues exist that could be resolved through a greater strategic understanding of humanitarian supply chain management, there are forums which could play a role, but many are pseudo-political and therefore unacceptable to some stakeholder organisations.

The main analytical output of the applied abstract reasoning analysis picks up on many of the theoretical sampling themes in the primary data analysis. Issues regarding ownership and control of elements of the humanitarian supply network are of a concern to Host Nation authorities, while Global Logistic Cluster staff and NGOs feel loathed to involve themselves in political issues. The management and flow of information are considered to be of paramount importance across all five cases, with stakeholders being informed of the network contacts that can enable the effective delivery of aid and the areas to avoid because of the frictions impacting effective aid delivery. All five cases occurred prior to 2020 and therefore the loss of face-to-face relationships due to remote working was not the issue that it has subsequently become. However, the case studies bore out the importance of direct contact and stakeholder relationships in general. They also demonstrated how the Global Logistic Cluster has developed between 2015 and 2020 into a forum which underpins stakeholder relationships and the passage of information in humanitarian supply networks. The linking of two of the four disaster management cycle phases across the response-development continuum, was specifically raised.

The substantive theory from the grounded theory analysis and the data from the applied abstract reasoning are synthesised using iterative triangulation, as described by Lewis (1998), to allow theoretical conjectures to be made. These inferences are founded in the interview and case study data and can be traced back to their origins through the analytical processes. The resultant 'expanded conjectures' are used to refine each substantive theory, thereby facilitating the emergence of a justified position for the theoretical case. Using iterative triangulation, the characteristics of the theoretical case were identified

and grouped in accordance with the themes derived from theoretical sampling. Iterative triangulation confirms that the primary concern for humanitarian supply network practitioners and managers is the lack of cohesion among stakeholder organisations due to inefficient passage of information due to an absence of a holistic approach to aid delivery. The data indicates that while every disaster relief operation is unique, operations share common characteristics which can be captured in a theoretical case. The conceptual model must be capable of delivering a holistic view of a humanitarian logistic operation, and while cognisant that each operation will be distinct, the way in which it will function will change little from one operation to the next. Therefore, the model can be cybernetic.

The Conceptual Model

The Viable Systems Model (VSM) and Soft Systems Methodology (SSM) are just two systems thinking approaches described by Flood and Jackson (1991); others include Systems Dynamics (which places its emphasis on structures and processes, and how these shape behaviour) and Critical System Heuristics (which emphasises the importance and role of boundary judgements). Yolles (1999) takes the view that VSM is applicable for an organisation seeking to improve the control mechanisms proposed to be essential for that organisation to be viable, while Jackson (2000) views SSM as being capable of tackling vague and unstructured problems. Preece, et al (2013) suggest that VSM is particularly applicable in functionalist research while SSM is more suited to research of an interpretivist nature; however, they echo the thoughts of Jackson (2000) by recognising that VSM is not so rigid as to not be valuable in undertaking more interpretivist work. Therefore, by taking advantage of the potential compatibility of these two approaches, the complexities of humanitarian supply networks can be addressed. This is because VSM can be applied to the system in a harmonious steady state, while Checkland (2000) demonstrates that SSM can resolve the conflicts that throw the system out of its steady state.

Duddy, et al (2019) details how VSM and SSM can act together to create a cybernetic solution for a humanitarian supply network to operate holistically. They demonstrate in Fig. 5 below how several humanitarian supply chains can come together as a viable system based on VSM, to work coherently and harmoniously, using effective and efficient information flows to avoid the circumstances that cause conflict between supply chains. Where the viable system is thrown out of steady state, the Systems World principles of SSM can be used to resolve the conflict.

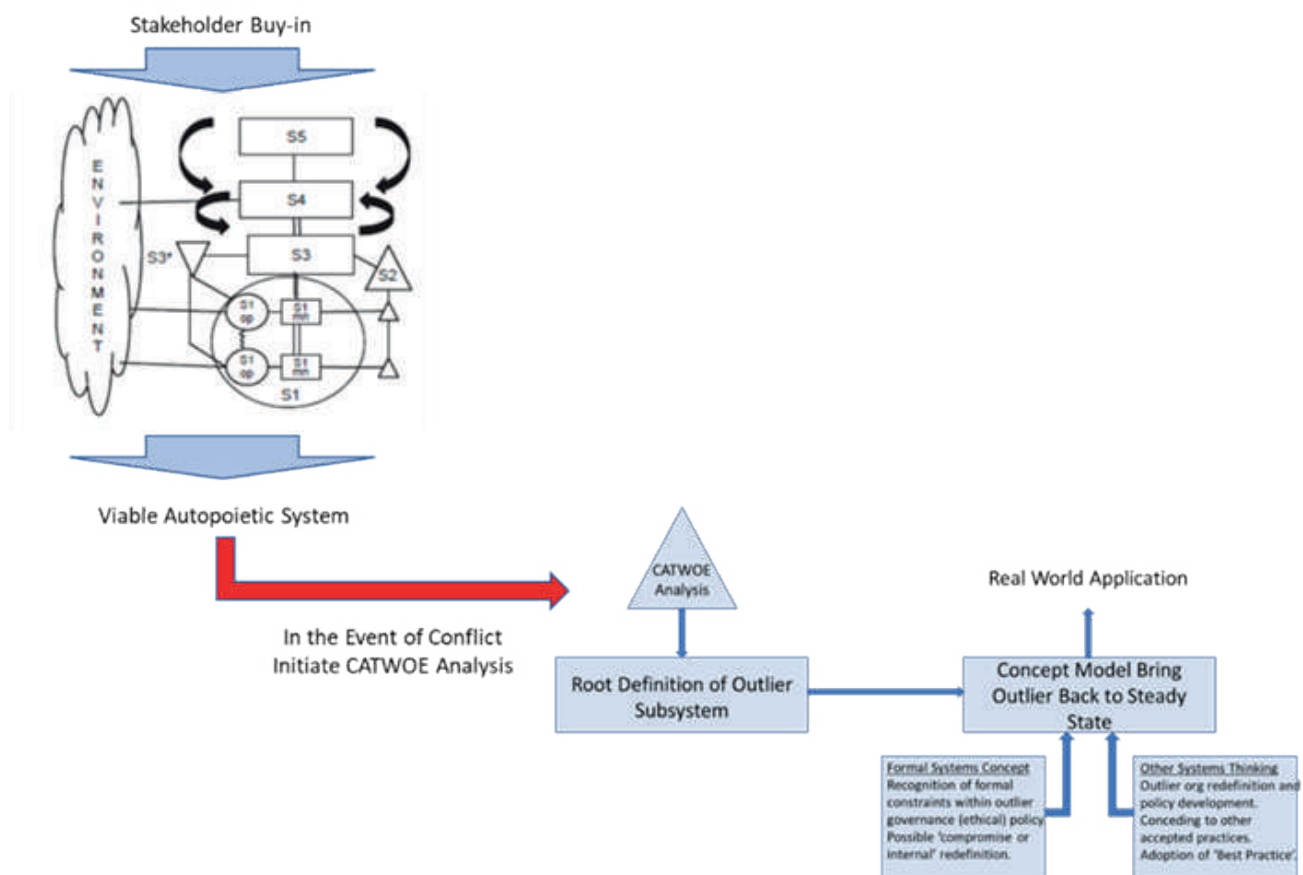


Figure 5. Humanitarian Supply Network Cybernetics Conceptual Model.

The theoretical case allows the humanitarian supply network paradigm to be modelled as a VSM system that experiences conflict which is resolved through the application of SSM. The feasibility is confirmed by the ability to formulate the root definition of a conflict occurring in a primary data scenario:

A system owned by no one stakeholder organisation which, under the environmental constraint of supply chain disruption caused by ISIS combat operations, transforms the scarcity of essential supplies into the provision of essential supplies by activating contingency plans and reserve stocks, the transformation being carried out by the NE Syria Forum and directly affecting the refugee camps administrators in providing relief to refugees. The world-image which makes the transformation meaningful includes the Dunantist ethos of each INGO, the shared determination to overcome the supply chain disruption and the impartial and politically neutral humanitarian values of each party.

Discussion and Conclusion

The analysis of the data collected from interviews and secondary source material captures the principal concerns experienced by practitioners and stakeholder organisations during disaster relief supply chain operations. The literature review which forms part of the doctoral research to which the data pertains demonstrated the need for a more holistic approach to be taken when supply chain stakeholders operate in such complex, unstable and austere conditions. The research methodology allowed a theoretical case to be constructed from iteratively triangulated data which was validated for its feasibility but not its practical utility. The research indicates that by taking a systems thinking approach, a conceptual model comprising a viable system based on VSM theory, supported by elements of SSM theory could allow a humanitarian supply network to operate in a harmonious steady state but which, when impacted by a force which cause it to become unviable, could be returned to viability through the application of Steps 3 and 4 (the 'Systems World') of Soft Systems Methodology. While others have applied Complex Adaptive Systems and the Systems Dynamics model to specific elements of humanitarian supply chains (Schiffing, et al, 2020; Besiou and Van Wassenhove, 2021), this is the first time cybernetics has been applied to a humanitarian supply network as a whole. The research recognises that a significant challenge exists in terms of practical governance, control and ownership aspects of VSM's S5 function, but it posits that through convergent development of existing operating procedures and governance practices, and stakeholder buy-in at the strategic level, an autopoietic solution could be achieved. Such a development in humanitarian supply chain management would have a significant benefit to stakeholders, donors and beneficiaries of international aid. It could provide a more efficient platform upon which to deliver aid, resulting in greater volumes delivered for the same level of funding ('more bang for the buck') and it would allow stakeholders to work more collaboratively, with organisations perhaps being more specialised in areas of high proficiency while working in partnership to become a more effective supply network component rather than a disparate, under-supported supply chain.

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DECISION SUPPORT FOR SOCIALLY SUSTAINABLE SUPPLY CHAINS - A LITERATURE REVIEW

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INTRODUCTION

The inherent business focus on economic and environmental issues within the sustainability supply chain framework has overridden the concept of addressing social issues in the value chain, thus emerging inclusion of social context in supply chains has become critical to the overall sustainability strategy and implementation by organizations (Zorzini et al, 2015; Ashby et al, 2012). Despite being under explored in time past, Social Sustainability Supply Chains addressed as the “Triple-S-C-M” for the purpose of this paper have become an integral part of the study of sustainability amongst stakeholders (Mani et al, 2016). This concept has necessitated the need to address the operational impact of supply chains not only from an Economic or/and Environmental view but from an impact on the overall well-being of the society.

As an emerging topic within the sustainability framework, Triple- S-C-M brings to light the interactive play between organisations and society. Research documenting various societal interplays and dimensions within supply chains is currently at different stages of maturation, and as such, there is a need to continue to contribute to its evolution as a matured discourse (Abbasi, 2017; Nakamba et al., 2017; Reefke and Sundaram ,2017).

Whilst some authors have argued about the interdependency of Social Sustainability Supply chains with other forms of Sustainability – Economic and Environment (Malakar and Lu, 2021) Other authors posit that Triple- S-C-M should be treated as an independent concept and dimension of sustainability (Klassen and Vereecke, 2012; Sachs (1999); Assefa and Frostell 2007; Huq et al, 2016). These inferences about its ontology highlight the importance of conducting more studies to arrive at a common understanding of its role in the sustainability ethos.

Despite being an emerging topic within the research sphere, there have been varying definitions attributed to several authors on Social Sustainability within the Supply chain and no consensus is currently seen in literature. By examining representative definitions (Carter and Rogers, 2008; Klassen and Vereecke, 2012; Eriksson and Svensson, 2015; Sodhi, 2015; Mani et al., 2016) we define Triple- S-C-M as

“Organizational capacity and capability inclusive of systems and strategy that addresses all forms of social responsibility within its focal supply chain and other multi-tier supply chains in its network that directly affect inherent stakeholders and target the overall wellbeing and safety of society.”

Motivation

Interactions between society and business necessitate indicative measures to assist in determining the level of corresponding action of business to society and action of society to business (Goebel et al, 2012). These indicators, known as social indicators, provide the lens through which the cause and effect of societal relationships to business is examined.

Due to these social indicators’ ephemeral and subtle character, most industries and organizations find it challenging to map and identify them. Two key trade sectors—resource-intensive and labour-intensive industries—are at the centre of social issues. Agriculture (including the textile and garment industries), Extractive Industries (including the mining and the oil and gas industry), and other trade sectors within these fields are hotspots for numerous supply chain social issues mainly because these issues are unseen and not at the front burner of strategic organizational ethos (Stahl & Sully, 2014., Baumann-Pauly et al, 2018).

Organizations' supply chains are vulnerable to threats and disruptions due to the unpredictable and nebulous nature of social concerns within the supply chain network. These escalating problems and effects observed in the supply chains of various industries, particularly over the past decade, as reported by the media and evidenced by public outrage, necessitate identifying the need to develop strategies and decision support mechanism for addressing socially sustainable supply chain (Mani et al., 2020, Zorzini et al., 2014, Yildizbasici et al., 2020, Koksai & Strahle, 2021).

Decisions making for social issues are fuzzy, asymmetric, and vague in addressing the issues, as a result of varying perspective from stakeholders. This is also due to the variety of parties involved in supply chains and as such indicators tend to be transitory and challenging to foresee (Wu et al., 2021). The interconnected nature of the system, as well as the inherent risks and potential consequences of ignoring social factors makes the process of decision making onerous. Thus, SC Organizations lack consistent criteria for making decisions about the visibility and impact of social concerns throughout its network (Bai and Sarkis, 2010).

Research Objectives

Taking cognizance of the current research opportunity within the Triple- S-C-M framework and decision support for Managers, this literature review aims to synthesize the findings from a wide range of scholarly articles into a coherent whole that can serve as a decision support guide to implementing Social Sustainable Supply Chain Management (Triple- S-C-M) in practice and decision support system required at every phase of development. We use a two-prong approach in our review, first we introduce a conceptual framework upon which organizations can implement in their quest for overall socially sustainable supply chain management adaptation. Secondly, a posteriori-decision-making tool adapted from the Cynefin framework (Snowden and Boone, 2007) of decision making to address specific social concerns in supply chains. This will be accomplished by elucidating two review questions:

- To what extent is the study of decision support for Social Sustainability Supply Chain Management investigated? (RQ1)
- What Dimensions and Indicators are used to assess Socially Sustainable Supply Chain Management in practice? (RQ2)

As a contribution to the body of knowledge, this study recognizes social concerns in supply chains into four primary themes (spectrums and dimensions) – Human Rights (HR), Occupational Practice (OP), Operational Business Practice (OBP), and Stakeholder Engagement (SE). We also contribute to the body of literature that studies decision support systems required for adopting socially sustainable supply chains, by categorizing them into five problematization sub-domains of, Disorder, Complex, Complicated, Simple, and Chaotic based on Cynefin Framework (Snowden and Boone, 2007). The next section provides the development of framework upon which the thematic analysis of literature content is premised, methodology used, the descriptive and content analysis, discussion, and conclusion.

CONCEPTUAL FRAMEWORK

Several bodies of work encapsulate the study of social issues within the supply chain. Research on Supplier Evaluation (SE) and Supplier Selection Criteria (SSC) has been at the heart of the conversation, as Suppliers are central to achieving sustainability within an organization (Mani et al., 2014; Najjar et al., 2020). This emphasis corroborated by Eriksson and Svensson, 2015 highlights the supplier's importance in organization's sustainability practices of its supply chains.

Considering the need to expand the conversation beyond SSC and SE, we propose a foundational context for insight that addresses RQ1 and RQ2; an IARP (Identification, Assessment, Resolution, and Performance Review) framework based on Gracia and Quezada, 2015 is proposed as a decision-making approach towards socially sustainable supply chains. Our theoretical framework is informed by the construct development and conceptualization heterogeneity discussed in Durach et al.'s, 2017 study and guideline on systematic literature reviews. This framework provides the basis for the thematic analysis conducted in our review.

This framework approach takes cognizance of the interlink of four theories that holistically approaches Triple- S-C-M) based on an organizational theory lens, stakeholder theory, legitimacy lens, and Decision-making theory. The amalgamation of theories for the framework construct allows us to make decisions that comprehensively address social issues within the supply chain beyond the ongoing extant literature discussion of SE and SSC.

Management theory discusses how organizations' internal dynamics and connections to external factors shape the behaviour that ultimately lead to success. These behaviours driven by effective decision-making requires intra-organization and inter-organizational linkages (Riordan & Fairbrass, 2014). Subsequently, organizations require the link of its internal organization and relationship with its external stakeholders to succeed, and to buttress this linkage; we reference the Stakeholders theory, whose core element is concerned with organization's relationship with its stakeholders (Walsh et al., 2005). Additionally, legitimacy lens highlights the importance of aligning organizational operations with societal norms (Erghott et al, 2011), thus underscoring the need for stakeholder linkages that enables sound decision-making. Organizations effectively succeed at aligning with social norms when the right decisions that affects its stakeholders are made. Through decision theory, the analogy of organizational choice and selection of varying paths of action is elucidated.

Based on the overarching assumption of management theories, which emphasize the importance of internal dynamics, external factors, stakeholder relationships, and societal alignment, this IARP conceptual framework development encompasses four interconnected elements.

- **Organizational Social Criteria and Indicators:** Drawing on the insights from management theory, the first element involves identifying and prioritizing social issues within the organization. This process utilizes frameworks such as stakeholder theory to understand the diverse interests and concerns of stakeholders (Walsh et al., 2005).
- **Supply Operations Network and Relationships:** Building on the idea of intra-organizational and inter-organizational linkages, the second element focuses on the supply operations network. It examines the relationships and interactions with suppliers, buyers, and other relevant actors that triggers the hotspots of social issues. These relationships influence the emergence and impact of social issues within the supply chain (Riordan & Fairbrass, 2014).
- **Management Actions for Issue Resolution:** Informed by management theories, particularly the legitimacy lens, the third element centres on management actions to address identified social issues. Organizations need to align their operations with societal norms and develop strategies for social responsibility, guided by ethical considerations and the need to gain legitimacy (Erghott et al., 2011).
- **Social Responsibility Performance Review:** The final element, consistent with management theories, involves evaluating and enhancing the organization's social performance. Social responsibility performance reviews and maturity models assist in measuring progress, benchmarking against industry standards, and continuously improving practices.

By linking these four elements to management theories, organizations can develop a comprehensive approach to sustainable and ethical practices in their supply chains. This approach ensures the effective identification, assessment, resolution, and review of social issues, promoting long-term success and societal impact. The IARP framework is broken down and summarized in Figure 1. The next section delves into the methodology of the SLR.

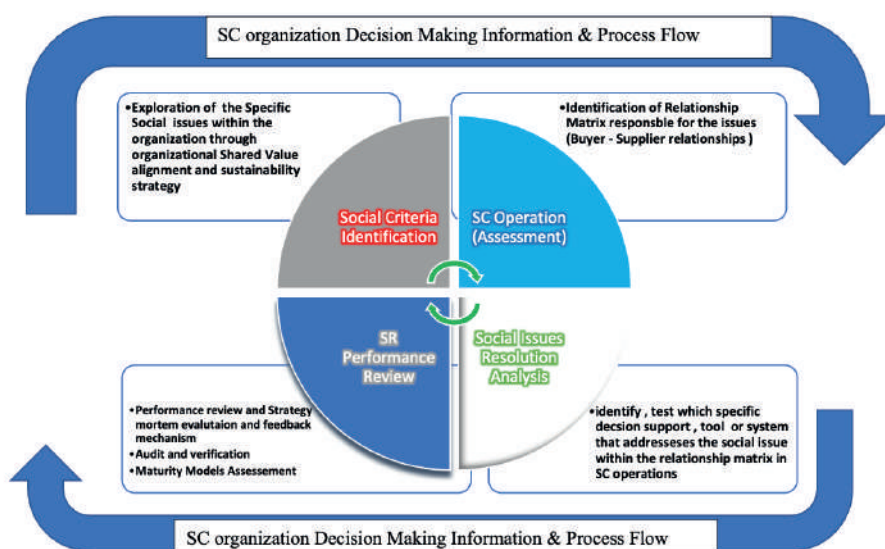


Figure 1: Framework to Address Decision-making for Triple-S(CM) within Organizational Supply chain. (Adapted from Gracia and Quezada, 2015)

METHODOLOGY

Following a set of processes (Denyer & Tranfield, 2009), this research was conducted in a method that is both transparent and repeatable. These processes include planning, searching, screening, extracting, synthesizing data, and reporting the results. In the planning phase, a scoping study was conducted to provide context and establish the research question. The search bubble architecture was used to connect research areas and guide the development of inclusion and exclusion criteria. In the searching phase a systematic search was conducted using keywords and the “AND” operator in major business databases. This allowed for the identification of relevant literature on evaluating social issues, decision support, and sustainable supply chain management. The chosen databases were SCOPUS, EBSCO, and ProQuest. The search aimed to address the research question and provide a foundation for the developed framework. Figure 2 elucidates on the paper selection process.

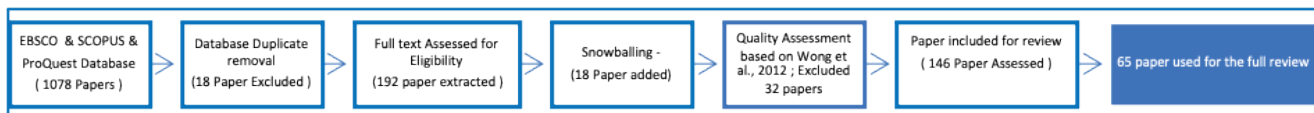


Figure 2: Paper Selection Process

DESCRIPTIVE ANALYSIS

This section provides a descriptive analogy of the study. The earliest paper that matches this study was seen in 1999 and a plateau trajectory was seen until the year 2014. This trend is because social issues were under explored within the sustainability ethos. An upward trajectory from 2014 indicates a growing awareness of the topic within the academia and thus provide the assertion for continuous study in this sphere. Three Journals – Journal of Cleaner Production (JCP), Sustainability and International Journal of Production Research (IJPR) accounted for the most articles within the decision support and social sustainability ethos. Also, there is a general increase in publication within management.

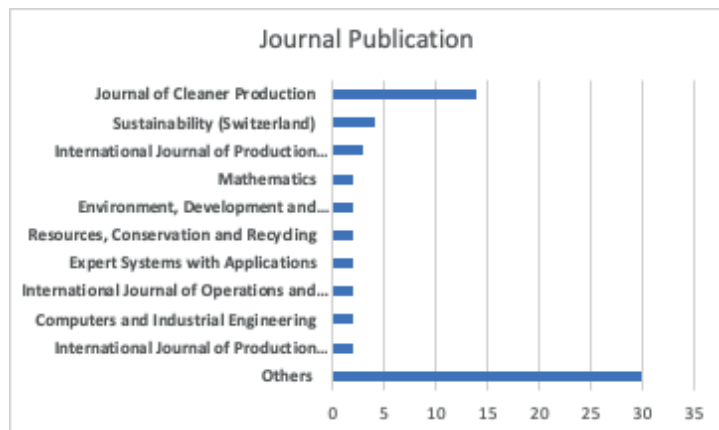


Figure 3: Article distribution across Journals

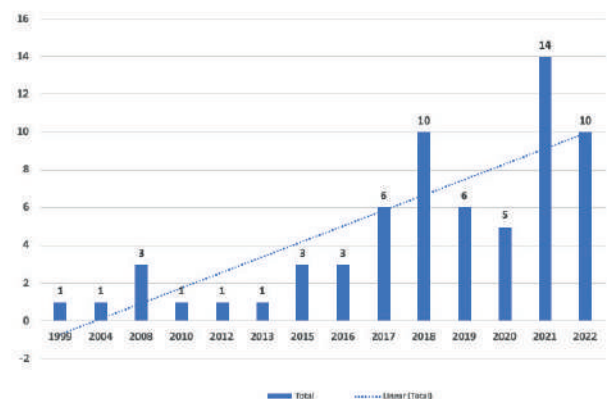


Figure 4: Article distribution by Chronology.

THEMATIC ANALYSIS

Using the decision-making approach framework from figure 1 as lens for our thematic analysis, three construct(s) are elucidated in the following subsections.

Social Indicators Identification

In addressing the complex relationship between corporations and civil society, the term “social criteria” is often used to describe the lens through which a range of social concerns can be evaluated. Due to the changing nature of the business and the proliferation of social interactions, interconnections, and interdependence between different tiers of organizational

value chains, these criteria have increasingly widened over the past decade (Yawar & Seuring, 2017; Kano et al., 2020). As a result of these evolving tendencies, organizational approaches to managing criteria within its supply chain are continuously evaluated for performance. Thus, for decision-making, managers must critically review the organizational exposure to varying social issues within its value chain (Sarkis, 2012). In this study, we utilized varying standards and guidelines as baselines for decision-making. We synthesized social criteria across sectors and validated our profiling from established literature through text mining using NVIVO. Based on this, four (4) social themes are observed, namely – Human Rights, Occupation /Labour Practices, Operational /Business practices, and Stakeholder engagement. There are also 33- indicators identified from these major categories as extrapolated. An assessment of the identified literature indicates that seven social indicators are frequently used as indicators for the purpose of decision making, these includes:

- Collective Bargaining Agreement and Freedom of Association – HR1
- Health and Safety at Workplace – OP4
- Equal opportunities and non -discrimination -HR3
- Employee Slavery and Servitude (Forced Labour)- HR2
- Human Capacity Development & Employee Training -OP5
- Stakeholder engagement – Host community – SHC
- Stakeholder engagement – Consumer(s) – SC

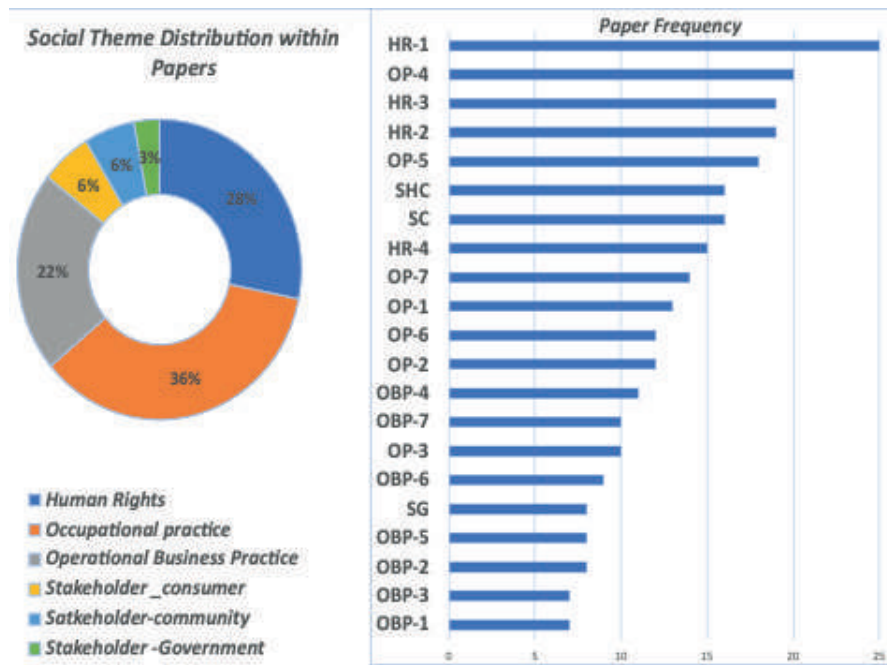


Figure 7: Social Theme Distribution and Indicator Frequency

Supply Network or Operations Network- Assessment

Assessing and improving supply chain processes is crucial for social sustainable adoption within an organization (Najjar et al., 2020). To guide our analysis and determine the direction of our paper, we rely on the Supply Chain Operational Reference (SCOR) model. The SCOR model categorizes supply chain processes into Plan, Order, Source, Transform, Fulfil, and Return, and further classifies them based on product and service segments. By understanding the relational matrix and considering the various tiers of the supply chain, we can identify and address significant social concerns or hotspots (Nakamba et al, 2017; Sancha et al, 2016). Utilizing the SCOR model as a framework for analyzing the selected papers, we identified a notable concentration on the operational model called Transform Product. This model encompasses a comprehensive range of activities involved in creating products, including manufacturing, assembly/disassembly, maintenance, repair, operations, and services. Notably, the literature emphasized the criteria associated with supplier selection within the context of this operational model. It also revealed that two major social criteria were prominent in the context; Health and Safety at workplace (OP-4) and Human Capacity Development (OP-5) and were most used as criteria for decision-making.

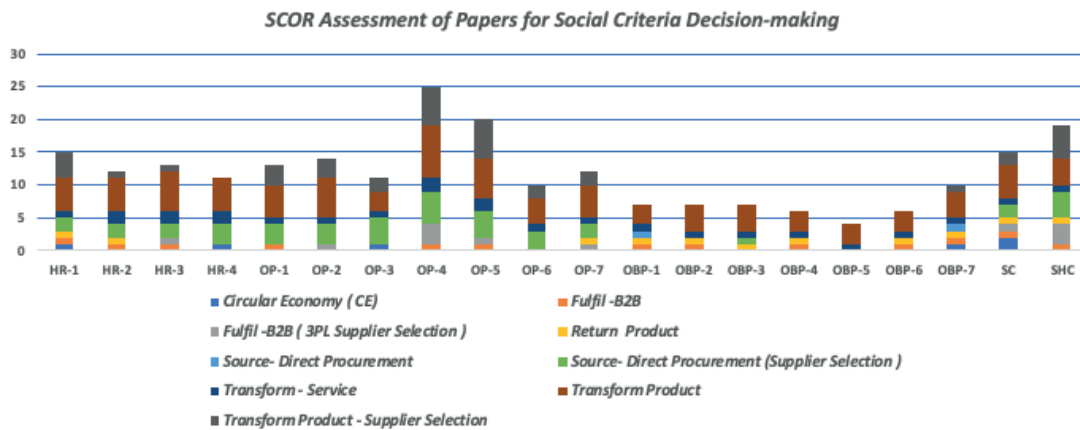


Figure 8: SCOR Assessment of Papers

Resolution via Organizational Management Tool – Decision Making

Resolving social issues and failures in supply chains necessitates proactive action from management, which can be facilitated using decision support tools or support strategies (Brandenburg et al., 2014). Decision support tools can take the form of structured, unstructured, or hybrid models. Structured decision-making approaches, such as statistical methods, artificial intelligence, and mathematical programming, have gained traction in driving effective decision-making (French et al., 2005). Both structured and unstructured decision support approaches offer unique benefits and can be leveraged based on the specific context and desired outcomes.

In the analysis of the papers, a priori-approach was employed for decision making, primarily utilizing multi-criteria decision models (MCDM) such as Analytic Network Process (ANP) and Analytic Hierarchy Process (AHP). These models were chosen for their simplicity and ease of use in weighing factors. The weights obtained from these models were then transformed into Triangular Fuzzy Numbers (TFN) or Binary numbers to facilitate a linguistic model for ranking purposes (Marzouk & Sabbah, 2021). Additionally, other heuristic and programming models were utilized to rank suppliers based on the established criteria weights.

DISCUSSION AND CONCLUSION

The thematic framework highlights the need for a decision support system throughout the supply chain flows of an organization, encompassing identification, assessment, resolution, and performance evaluation stages of Triple S-CM. Organizations prioritize social criteria that contribute to the social reputation of their supply chains. Key social criteria such as Occupational practice (Health and Safety at the Workplace), Human Rights conditions (Collective Bargaining Agreement and Freedom of Association), and Stakeholder engagement with Customers and Host Communities are given prominence, influencing supplier selection, evaluation, and identification of social issues within the value chain.

Assessing hotspots of social concerns within the supply chain is a crucial decision-support step for adopting a Triple S-CM approach. The SCOR model highlights the Transform Product process as a prominent hotspot in the value chain, although it is important to acknowledge that social constructions can vary by sector and geographic location. A case study (Kohksal & Strahle, 2002) in the fashion industry in Indonesia and Vietnam sheds further light on social failures during the product transformation process. Issues related to health and safety at the workplace, contractual agreements (overtime issues), cultural differences, and Forced Labour were identified as significant hotspots for social failures within the industry.

Utilizing decision tools to address social issues through supplier assessment, selection, and development mechanisms is crucial for achieving social sustainability in the supply chain. However, most decision support tool uses a priori approach for decision making, an approach that requires inference on predetermined social criteria based on expert knowledge to aid decision making. To further advance the literature on decision making for socially sustainable supply chain, we propose a Posteriori approach using a sense making tool called the Cynefin framework by (Snowden and Boone, 2007). The Cynefin framework adapted for socially sustainable supply chain decision making categorizes social issues into four problematization domains – Simple, Complicated, Complex and Chaotic domains. The use of Cynefin decision-making framework as a lens for decision support would help practitioners in identifying, assessing, and responding to social issues within its supply chain.

It's our believe that the framework could help managers by offering a structured approach to decision-making. It also helps to identify blind spots and bias and promotes adaptive decision-making.

The figure below places several social criteria within the four-decision making domain of Cynefin framework. Some Criteria straddle between two domains as they can be seen to be on two spectra in some context. Thus, we present each criterion to different decision frames. In doing this Managers can effectively respond to social issues based on the where the issue is placed in the framework. As a classic example, a typical social issue within the Chaotic quadrangle, would mean an "ACTION" is required first as response to the issue before a SENSE making response is executed. An action could mean a temporary suspension of production in a factory and a self-reporting mechanism to regulators where it's reported that the use of child labour has been noticed in a recruitment process during a supplier audit.

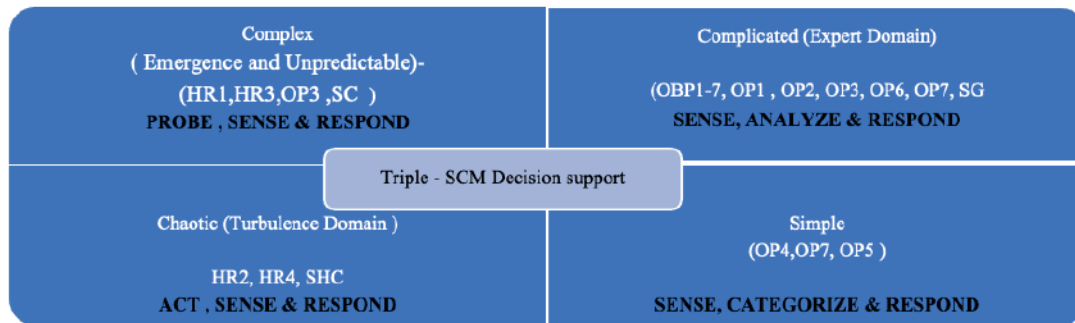


Figure 9: Decision Support Framework for Socially Sustainable Supply Chain, adapted From Cynefin Framework (Snowden and Boone, 2007)

In conclusion, this research examines decision support, social sustainability, and supply chains, utilizing a systematic literature review to understand the relationship between social elements and supply chain processes. The analysis of 65 articles revealed four prevalent social concerns that form the foundation of a supply chain's social reputation. The Cynefin framework is proposed as a decision-making tool to assist managers in their adoption of a socially sustainable supply chain. However, the study acknowledges limitations in the focus on the earlier stages of the decision flow and suggests that future research should explore decision support for social performance and test the Cynefin framework adaptation hypothesis through case studies in specific geographic locations or industry.

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A SURVEY ON UNETHICAL SUPPLY CHAIN PRACTICES IN CONFLICT REGIONS

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Introduction

Due to chaos and anarchy in conflict areas, operations and supply chains are often run in an illegal and unethical way that threatens economies, societies, and ecosystems (Pullman, et al., 2023). In particular, the Russia-Ukraine war constitutes a major geopolitical disruption that has generated several bottlenecks and complications in food supply chain along with numerous unethical practices. As a results, several thousand tons of grain were smuggled in the Black Sea during the war (Financial Times, 2022).

Research on ethical supply chains and ethics in supply chain setting has known a steady increase (e.g., Kaynak et al., 2015; Bag et al., 2018). Yet, it is recently that scholars have started to give attention to unethical behaviours in supply chains (Pullman, et al., 2023; Zhang et al., 2022; Liu, 2022). In extant literature, unethical behaviours were often viewed from the buyer-supplier perspective and omit the interaction with geopolitical environment which is prevalent in conflict regions. Along with the recent efforts to integrate the political dimension in supply chain management research (e.g., Grover and Dresner, 2022; Roscoe et al., 2022), we seek to develop a theoretical model of unethical supply chains (USC) drawing on new institutional economics and hybrid governance theories. In doing so, this research helps connect supply chain with other disciplinary fields from institutional and political economy domain. Furthermore, we underline the characteristics of USC as networks with hybrid governance in conflict regions using supply chain design principle from established SCM literature (Chopra and Meindl, 2019; Roscoe et al., 2022). Accordingly, we present the USC design based on complexity, formalisation and centralization of activities as well as power and resources distribution. The purpose of this paper is to investigate unethical supply chain practices in conflict area with a specific reference to the Russia-Ukraine war. To achieve the objective, this paper adopts a two-step method. In the first phase, a literature review is performed to define the state of knowledge on the topic and provide inputs to design the data collection guide to be used during interviews. In the second step, semi-structured interviews are carried out with logistics and supply chain managers and geopolitical experts operating in different countries.

This paper is structured as follows. In the next section, the literature review and motivation for this research are presented. In the third section, the methodology used has been described. The fourth section presents a summary of the preliminary empirical evidence collected. The final section provides concluding remarks and some implications to mitigate unethical practices in SCs before highlighting the contributions of the study and further research avenues.

Literature review

Unethical supply chains

Ethics in supply chain has begun its emergence in the early 1990s (Emiliani, 2010). Ethical supply refers to the practice of providing goods and services to customers while subscribing to an ethical code (Beamon, 2005). Illegal activities and unethical behaviours of organizations are often scrutinized and sanctioned by society (Svensson and Baath, 2008). Ethical discussions revolve around firms' behaviours, legal structure, moral limitations, and determination of ethical principles, individual and/or group responsibilities and compliance with the specific norms (Manning et al., 2006). The source of unethical behaviours in business can be traced back to the ethical climate and policies carried out by the entity (Badenhorst, 1994). Unethical practices observed in many forms include, in addition to outright fraud, unfair competition and communication, non-respect of agreements, and unfair attitudes and treatment of stakeholders (Freeman, 1984; Fassin, 2005). The presence of unethical behaviours affects the duration of the relationship established between the buyer and the supplier. Unethical behaviours provide short-term gains for the parties; however, it shortens the duration of the relationship between the partners and eliminates the long-term gains (Hill et al., 2009). The literature indicates that unethical implementations between buyers and suppliers are the result of two reasons; one of them is internal and the other is external (Carter, 2000b). The internal reasons include features related to the organization such as leadership approaches, personnel's behaviours, sanctions, training, policies, and pressure towards achieving success. The external reasons include inter-organizational features such as the structure of the government, the duration of the relationship, and the balance of power. Extant literature often views ethical issues in a buyer-supplier relationship perspective (Turner et al., 1994; Carter, 2000a; Das, 2005). Several studies have examined the antecedents of unethical behaviours. Thus, lower levels of unethical behaviour are associated

with the establishment of a corporate formal ethical policy, providing ethics training programs, periodic review sessions, rewards, sanctions, and positive examples set by management (Carter, 2000a). Unethical attitudes and practices such as subtle, deceitful behaviours negatively affect the credibility, image, and reputation of the entity (Hill et al., 2009; Carter, 2000b, Das, 2005).

Based on these premises, literature on unethical supply chains was mainly focused on purchasing, dyadic supply chains and buyer-seller transactions. Consequently, the scope of several studies was on firms, not on networks or supply chains. In addition, previous studies have highlighted unethical behaviours related to fraud, deceit and faulty sellers and there was no mention of the geopolitical context influence. To reveal these dynamics of USC, this paper develops a hybrid governance approach that revisits and redefines the major governance challenges of USC as hybrid governance networks. The approach makes use of concepts and relations from socio-institutional theories in social science, such as theories on multilevel governance and social innovation (e.g., González and Healey, 2005; MacCallum, et al., 2009; Moulaert et al., 2013), and theories on the relationships between reproduction, regulation and forms of governance (Swyngedouw and Jessop, 2006). These theories mobilize concepts and relations capable of theorizing the hybridity and multi-scalarity of USC constituting governance systems.

Supply chain network structure

A supply network refers to a network of firms engaged in manufacturing and assembly of parts to create a finished product. The membership in a network and its organization vary for a given product and over time. The operation of a supply network can vary tremendously depending on policies, practices, and shared history. As a first step toward characterizing USC structure, we draw on literature related to SC networks design (Chopra and Meindel, 2019). A supply network is essentially an organizational form of a system of firms and its structure can be captured in the following three dimensions: formalization, centralization, and complexity.

Formalization is closely associated with standardization (Mintzberg, 1979; Pugh et al., 1968) through rules and procedures as well as norms and values (Beyer, 1984). Organizations formalize activities to ensure consistency of output over time, and such an effort may take place either in written form or unwritten form (Price and Mueller, 1986). A key variable that has proven to show positive correlation with formalization in empirical studies over the years is explicitness (Gerwin, 1984). Formalization requires rules and other behavioural guidelines to be explicit. Eventually, by keeping the rules and norms explicit and open, formalization will bring about precision and fairness. However, too much formalization may also lead to inflexibility and rigidity (Mintzberg, 1979). Therefore, formalization in the supply network context refers to the degree to which the supply network is controlled by explicit rules, procedures, and norms that prescribe the rights and obligations of the individual companies that populate it. The next level up from a simple dyadic relationship is a set of multiple dyadic relationships revolving around one firm. In particular, when this one firm is the buying firm, the entire set of supplier firms that it forms multiple dyadic relationships with is commonly referred to as the supply base. Much as a large organization would tend to be more formalized (Gibson et al., 1997), a large supply base (high number of suppliers) per given product might also be more formalized than a smaller supply base. Larger bases would rely on rules, procedures, and norms to achieve standardization and control their suppliers.

Centralization addresses the degree to which authority or power of decision making is concentrated or dispersed across the organization (Price and Mueller, 1986). If the decision-making authority in an organization rest on a single individual, the structure is said to be centralized. Conversely, if the decision-making authority is distributed among many individuals, then the structure is regarded as decentralized (Mintzberg, 1979). The key advantages of centralization are orderliness and economies of scale, whereas the key advantages of decentralization are responsiveness to local changes and an environment more conducive to creative ideas. In supply networks, centralization is related to how much authority or power the final assembler exercises over the suppliers in the network. In a centralized supply network, decisions would be made by the final assembler; in a decentralized network, decisions would be made autonomously by individual suppliers. Realistically, however, depending on the size of the supply network, the final assembler cannot possibly make decisions for all suppliers in the network. It will selectively get involved in decision making. Therefore, centralization in the supply network occurs in a linear context with respect to the final assembler. Perhaps, it is in this context that the term, supply chain, was first used. For instance, a centralized practice would occur when a final assembler exercised direct control over the top-tier supplier, the second-tier supplier, and so on.

Complexity refers to the structural differentiation or variety that exists in an organization (Daft, 1989; Price, 1972). Complexity can arise from the number of subsystems or the level of differentiation of varied goals that compete in an organization. Structural complexity is typically measured in three different ways - horizontal complexity, vertical complexity, and spatial complexity (Daft, 1989; Gibson et al., 1997). Horizontal complexity refers to the number of different entities in the same level, vertical complexity refers to the number of levels in the system, and spatial complexity refers to the number of operating locations (Daft, 1989; Price and Mueller, 1986). Sometimes, spatial complexity is referred to as the degree of dispersion among members within the system (Price, 1972). In the supply network, the measurement of complexity in terms of these three variables becomes rather straightforward once

a complete map of the supply network has been obtained. It would simply entail counting the number of tiers (vertical complexity), the number of suppliers in each tier (horizontal complexity), and the average distance between two firms engaged in buying and supplying (spatial complexity).

Methodology

To achieve the objective of the study, a two-step research method has been adopted. In the first step, a comprehensive literature review is performed to define the state of knowledge on the topic and to provide inputs to the empirical part of the study. In the second step, semi-structured interviews have been carried out with managers of logistics service companies and geopolitical experts. The interviews have carried out in three different countries such as France, Portugal and the UK (Scotland). Data collection guides (DCGs) were created, and a formal interview protocol was developed (Yin, 2018). Initially, two different DCGs were created on the basis of literature review: one for the managers of logistics service providers and one for geopolitical experts. The DCGs were designed on the basis of the existing literature and inputs received during focus group meetings. In fact, such DCGs were discussed in an online focus group meeting where the motivations of the research and the content of DCGs. The focus group was participated by academics, and researchers working in the logistics and supply chain field together with geopolitical experts and managers of logistics service providers. The objective of the online focus group meeting was to obtain feedback on the appropriateness of the study's objectives and questions, and their clarity and readability. After implemented the changes suggested by the participants of the focus group meeting, the final version of the DCGs included the following four sections: (1) demographic information; (2) general approach to unethical behaviour in supply chain; (3) supply chain design; and (4) political settlement and control and prevention mechanisms. Semi-structured interviews were conducted from May until early July 2023, at the companies' premises or, based on the preference of respondents, by video call. The semi-structured interviews had an average duration of one hour. Interview reports were prepared for data analysis. Information was also triangulated through secondary sources such as information retrieved in the international press. Transcripts of the interviews were shared with the interviewees and respondents were contacted by e-mail or phone to resolve discrepancies (Yin, 2018). Each interview was transcribed, and the reports of data gathered were analysed, assessed, and cross-examined to identify similarities and differences among answers coming from the respondents in the three countries involved in the research. The next section describes the preliminary results achieved from the interviews carried out.

Preliminary results

Considering that data gathering is still in progress, the conducted interviews involved three managers working in logistics service companies (in France, Portugal and UK-Scotland) and one geopolitical expert (in Scotland). Table 1 presents some demographic characteristics of the informants. The three LSP managers interviewed have all a long experience in the logistics industry (almost 12 years on average). The services provided are different and range from shipping and warehousing to temperature-controlled food logistics and consumer electronics distribution. The French and Portuguese LSPs are medium-sized companies while the Scottish LSP is a large company belonging to a multinational logistics group. The Scottish geopolitical expert interviewed is a university professor with no long experience.

	FRANCE	PORTUGAL	UK (SCOTLAND)	
Informant title	Executive (LSP)	CEO (LSP)	Centre Director (LSP)	Professor (Geop. expert)
Company location	HQ in France and braches in North and West Africa	HQ in Portugal and branches in EU countries	Scotland (part of US owned multinational)	Scotland (Heriot-Watt University)
Main activities of the company	LSP with focus on maritime transport and warehousing	Temperature-controlled food logistics and logistics services	Consumer electronics distribution; 30 years' experience	20+
Founding year	1996	2001	1999	1966
Employees 2022	75	>100	550 in Scotland; 18k globally	about 2,000
Turnover 2022	>100 M €	> 100 M €	US\$ 6.8 billion	About £300 M.
Experience	12 years	13 years	10 years	< 1 year

Table 1: Demographic information

In relation to the general way to manage unethical behaviour in supply chain (see table 2), the three LSP companies show a similar approach with some specific elements. Despite the fact that the three LSP managers provided different definitions of unethical supply chain practices, there is a substantial consensus on the definition of illegal practices. In this first case, the French manager stressed both breaking the law and unethical behaviours, the Portuguese manager highlighted the difference between what one thinks should be done and what is consciously done and the Scottish manager that linked the USC practices to environmental and social sustainability. For all the three interviewees illegal practices refer to practices that break the law in the region where they are performed. None of the three companies cover risks coming from their customer operating in the Ukraine region and then they do not have experience in managing USC behaviours of their customers. All three companies have dealt with USC behaviours of their customer in the past, but they adopted different measures to mitigate such risk. The French and the Scottish companies blocked collaboration with customers engaged in suspect activities and all operations are monitored by the legal team or investigated to assess them.

	FRANCE	PORTUGAL	UK (SCOTLAND)	
	Executive (LSP)	CEO (LSP)	Centre Director (LSP)	Professor (Geop. expert)
Definition of unethical supply chain practices	Practices that break the law and also when one of the members in the supply chain acts in an unethical way and commits fraud and corruption	When there is a difference between what stakeholders thinks it is being done and what is being done in a conscious way	Anything that conflicts with firm's sustainability (environmental and social) policies	A practice anywhere in the supply chain that contravenes good ethical practice
Definition of Illegal practices	Illegal means breaking the law	When the practices are not compliant with the law of the region where they are performed	Any practice that is in contravention of the law in any country of operation	Self-defining, depending on the jurisdiction
Covering risk of customer operating in the Ukraine conflict area	No but it is in some foreign markets	No	Operations ceased in Russia, Belarus and Ukraine in 2022	No
Experience in managing unethical SC practices in Ukraine	Recent events (covid-19, war in Ukraine) shown the importance of ethics in SC	No	No, the Ukraine war is not linked with specifically unethical supply chain issues	Highly relevant and now on the radar
Addressed unethical SC behaviour of customer	Yes	Yes	Yes	n/a
Measures taken to mitigate the risks of unethical SC behaviour of customer	Stop dealing with any partner that engages in suspect activities, all operations are monitored by our legal team	Be very clear about our interpretation of what was being done and be clear that we could not support it	Discontinuing the association in clear cases; initiating an investigation to establish the facts (with a variety of outcomes)	n/a
Adoption of code of conduct to face unethical behaviour of customer	Yes	Yes	Not a written code but rather a general statement of values, including those related to social sustainability	n/a

Table 2: Approach to unethical behaviour in supply chain

The Portuguese company stressed the need to be clear in interpreting suspect behaviours and not support them. The French and the Portuguese companies have a formal code of conduct in place to combat unethical behaviour of customers, while the Scottish company does not have a written code but rather a general statement of values, including those related to social sustainability.

In relation to supply chain design, one aspect relates to the effects of illegal SC on the economy and illegal practices that Russian authorities use to overcome sanctions. The informants present different views on this. The French and Portuguese LSPs indicate that Russian authorities overcome sanctions using tankers with faking flagship and turning off GPS for not to being tracked or through fake companies to allow goods to pass the borders. The Scottish company has no knowledge about this, while the geopolitical expert argued that sanction evasion is more difficult today than in the past. Looking at the effects of illegal SCM on the economy, it seems that beyond increasing corruption and taking economic advantage, such effects seem to be not so relevant. From the SC hierarchical point of view, it seems that there is not a specific rank in illegal supply chain. According with the Portuguese informant, often who plan and run illegal activities are at the same hierarchical level. The power in illegal SC seems to be in the hand of the buyer company. On the other hand, among informants there is not a clear idea about the other actors involved in illegal SC and who are the buyer of illegal products. Informants seems to have a more precise idea on how actors overcome sanctions and controls. The French company argued that actors involved in illegal SC escape sanctions using many people such as fake companies, lawyers, politicians, etc. The Portuguese company stated that this is possible through corrupted and complex organizational structures. A higher level of decision centralisation seems to increase the level of SC unethical behaviour in conflict zones according with the Portuguese company. The French company does not believe that a higher level of centralisation of decision may influences USC behaviour. The Scottish company stated that a balance between central (strategic) and local (operational) decisions is the best way to combat USC behaviour. Finally, all the four informants agreed that SC complexity has an increasing effect on unethical behaviour in the SC.

About political settlement, respondents do not have any evidence about clientelism issues in SC in the Ukraine conflict zone. Similarly, none of the respondents is aware about SC chain practices finalised to bypass sanctions and controls in Ukraine conflict zone. The opinion of respondents varies in relation on how the allocation of power in SC (distributed Vs concentration) affect unethical behaviour in Ukraine conflict zone. The French informant shows some scepticism that the allocation of power in the supply chain can influence unethical behaviour in the Ukrainian conflict area. The same scepticism is shared by the Scottish geopolitical expert. On the other hand, the Portuguese respondent believe that a more distributed power in the SC may mitigate unethical behaviour in that area. The Scottish LSP respondent argued that a balance between the concentration and distribution of power might reduce unethical behaviour in the Ukraine conflict zone. Interestingly, when the effect of distribution of SC resources on unethical behaviour in Ukraine conflict zone is considered, the respondents are all agree about the fact that a better distribution of resources in the SC may reduce unethical behaviour in such conflict zone. There are several control/prevention mechanisms to might reduce unethical SC behaviour. The French and the Portuguese companies indicated the adoption of code of conduct and ethics policy, focalization, strong penalties for such behaviour and more strict traceability rules. In addition, company should be in the position to be sure that its SC partners follow/implement the above mechanisms. Both the Scottish LSP and the geopolitical expert are convinced that the development of appropriate legal culture and awareness are the key to control and prevent unethical SC behaviour in conflict zones such the Ukraine.

Conclusion and implications

The results of this study constitute a first step towards understanding USC practices. In this respect, we have explored some aspects regarding USC design, structure and governance (power). Shedding light on USC practices interconnections with their structure and enablers would clarify how illegal behaviours develop and would help mitigate and limit their impact. The findings highlight how illegal and unethical practices in supply chains present different forms. In mitigating the risk of USC behaviours, different approaches are used such as blocking collaboration with partners engaged in suspect activities, monitoring of suspect operations by a legal team and identifying suspect behaviours and not supporting them. In relation to supply chain design, the power in illegal SC seems to be in the hand of the buyer company. On the other hand, SC actors overcome sanctions and controls using fake companies, lawyers, politicians, etc. Another finding indicates that a better distribution of resources in the SC may reduce unethical behaviour in conflict zone. The most important control/prevention mechanisms to reduce unethical SC behaviour are the adoption of code of conduct and ethics policy, focalization, and more strict traceability rules. On the whole, we suggest that the characteristics of USC are similar to networks with hybrid

governance in conflict regions which explains their structure, design, complexity and power. The results of this study based on LSPs, and geopolitics experts' views provide an understanding of USC practices related to the Russia-Ukraine conflict area. In doing so, we respond to the recent calls of several scholars regarding the need for a data regarding illegal and USC practices (Pullman et al., 2023). Moreover, the theoretical framework of the study draws on SC design theories as well as new institutional economics and hybrid governance theories to underline the hybridity and multi-scalarity of USC constituting governance systems. We see merit in deploying such theoretical approaches and we consider them can underline the structure of USC practices and how they endure facing sanctions and scrutiny. Consequently, this study contributes to logistics and supply chain management literature by providing insights into the current state of USC behaviour in conflict zones which can generate further research avenues. Specifically, this research helps connect supply chain management research with other disciplinary fields from institutional and political economy domain. At the practical level, the results of the study might be of use in public policy making, as well as among supply chain practitioners seeking to enhance the visibility and transparency of their operations. This study has been conducted on a limited sample of LSPs using qualitative approach. Limitations regarding generalizability are to be expected from such approach. In addition, the perspective of other partners in the supply chain was not covered. Finally, we were not able to have data on how USC governance and power structure. Accordingly, future studies might investigate other conflict zones and conduct interviews with other SC members coupled with data from reports on the field which would generate additional insights. Finally, survey based quantitative studies might be conducted to examine the influence of USC practices on resilience, performance and robustness of SC operations.

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A QUALITATIVE ASSESSMENT OF DIGITALISATION ADOPTION FOR SUSTAINABLE THIRD-PARTY LOGISTICS OPERATIONS THROUGH THE TECHNOLOGY, ORGANIZATIONAL, AND ENVIRONMENTAL (TOE) FRAMEWORK.

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1. Introduction

The global logistics industry was worth over 8.4 trillion euros in 2021, with a projection of exceeding 13.7 billion euros by 2027 (Placek, 2023). Although transport and logistics account for 12% of global GDP (CILT UK, 2023), they were hit by the COVID-19 pandemic in 2020, which slowed down international trade. However, the same pandemic provided a rare opportunity for freight forwarding companies through the rise of e-commerce (Placek, 2023). The scale and complexity of the operations, dynamic customer requirements (e.g. DPD UK's one-hour delivery window), and sustainability aspirations (e.g. Landflight Travel's all-green travel coaches) necessitate firms to employ digital technology capabilities to respond effectively.

Digitalization capabilities such as interconnectivity and predictive capabilities to deliver visibility through big data and the Internet of Things have gained attraction so the United Nations has recognised the role of digitalisation in achieving the 17 United Nations Sustainable Development Goals (SDGs) (UN, 2023). Sustainability refers to the integration of the environmental, economic, and social pillars (Triple Bottom Line, (TBL)) to prevent environmental pollution and demonstrate corporate responsibility while fostering prosperity for the firm and stakeholders (Elkington, 1998, UN, 2023). Third-party Logistics (3PL) services are major contributors to Greenhouse Gas (GHG) emissions due to extensive transportation activities, hence the urgency to reduce GHG by 40% - 70% between 2010 and 2050 (McKinnon, 2016). Logistics UK (2021)'s Manifesto highlighted the role of technology in achieving net zero sustainability targets, but much effort is required to realise this potential.

While researchers have studied 3PL outsourcing and strategies, limited attention was given to sustainability in 3PL operations (Evangelista, et al., 2018). Studies investigating digitalisation in the logistics industry have ignored a strategic focus on sustainability and limited their scope to areas like production logistics, just-in-time, etc. (Ilin, et al, 2019). Therefore, research on the role of digital technologies in achieving 3PL sustainability is incipient (Raji et al., 2021). While Parhi et al., 2022 examined the enabling factors for successfully implementing sustainable logistics, the study lacked focussed attention on the 3PL sector. This research addresses the gap by providing an exploratory study of the enabling factors for successful digitalisation adoption for sustainable operations in UK 3PLs using the technology, organizational, and environmental (TOE) framework. While researchers have applied the TOE framework to investigate digital technology adoption, they have failed to examine the ecological dimension of the environment. Therefore, this exploratory study makes a valuable contribution by investigating success factors for sustainable digitalisation adoption using the TOE framework to incorporate environmental sustainability in 3PLs through a case study research design.

2. Literature review

2.1 3PL Operation Sustainability

The rising scale and complexity of the 3PL logistics operations due to dynamic customer requirements and sustainability targets is evident since 28% of GHG in the EU was caused by transportation (McKinsey Sustainability, 2020), so the UN has set a net zero target for 2050 (CILT UK, 2023). Given the unique context of 3PLs, innovation through digitalisation is crucial on the journey to net zero emissions as they employ green technologies and sustainable energy sources. However, digital technology capabilities require careful configuration to achieve this objective. While environmental sustainability of supply chain activities has attracted some interest, extant literature is plagued with the following limitations of: (i) much focus paid to the manufacturing sectors, with little attention to service sectors like 3PLs (Evangelista, et al., 2018), (ii) studies on 3PL activities lack the focus on environmental sustainability, (iii) studies on environmental sustainability are non-systematic, hence, lacking theoretical frameworks (Woschank et al., 2021). Without a framework to define the digitalization adoption approach, the achievement of environmentally sustainable operations through digitalisation is at risk.

2.2 Digitalization in 3PL Operations

3PLs orchestrate and facilitate supply chain operations to achieve efficiency and create value for the customer and achieve competitive advantage for the firm (Zacharia et al., 2011). 3PLs manage complex operations involving all or part of a shipper's logistics operations at different locations including tracking and tracing, cross-docking, freight forwarding, etc. to create value (Novack et al., 2019). Although transportation management systems are employed for the planning and flow of logistics activities (Novack et al., 2019), nevertheless, the increasing complexity of logistics operations and sustainability demand necessitates the integration of intelligent systems and devices especially for outbound operations to provide resource planning and scheduling, travel route optimization, real-time monitoring, product traceability, supply chain visibility, and predictive information for proactive decision-making (Parhi et al., 2022). While the use of technological devices generates abundant data, the ability to synthesise and analyse data to inform decision-making remains a challenge (Ilin et al., 2019). 'Digital maturity' is needed to implement advanced digitalisation solutions because firms must develop digital capabilities (technological) and transformation management capabilities (organisational) to navigate the digitalisation journey and deliver sustainable operations, especially at the last mile (Cichosz et al., 2020). In addition, the impact of industry characteristics on digitalisation adoption for sustainability such as regulatory frameworks, target audience, etc., cannot be overlooked. Hence an understanding of firm digital readiness is required for the journey toward digitalisation through a digital assessment framework (Cichosz et al., 2020). Accordingly, this paper adopts the TOE framework to assess the success factors of digital technology adoption with a comprehensive focus on environmental sustainability.

2.3 Theoretical framework

The Diffusion on Innovation (DoI) theory has been employed to conceptualise firm adoption of digital technology and innovation (Rogers, 1995; Oliveira and Oliveira, 2011). Nevertheless, there is inconsistency in the operationalisation of the theory as some researchers (Mustonen- Ollila and Lyytinen, 2003) employed the theory based on five factors influencing the innovation adoption process while others employed three (Oliveira and Martins, 2011). This leads to diverse research outcomes. The inter-organizational system model (Iacovou et al., 1995; Al Hadwer et al., 2021) also considers organisational readiness and perceived benefits of innovation but lacks thorough consideration of environmental sustainability. Furthermore, the technology readiness index (Awa et al., 2017) and the theory of planned behaviour (Ajzen, 1991) are aimed at the technology adoption intentions of individuals rather than organisations (Al Hadwer et al., 2021), rendering them unsuitable for the aim of this study.

The TOE model provides a comprehensive framework for examining factors affecting digitalisation adoption from technological, organisational, and environmental perspectives, making it appropriate for this study. Though the model has been criticised for a lack of advancement since its inception in 1990 which makes it generic (Baker, 2012), nevertheless, its generic attribute provides flexibility for adaptation in different industries, hence researchers (Awa et al., 2017; Zhang et al., 2020; Al Hadwer et al., 2021) have applied it in different contexts. The technological dimension refers to digital technologies which generate distinct internal capabilities. The organisational dimension includes firm structural processes, resources, and characteristics which impact technology adoption (Seshadrinathan, and Chandra, 2021). The environmental dimension refers to the industry and market environment and sustainability, yet environmental sustainability has been ignored (Zhang et al., 2020) by extant research as shown in the studies reviewed in Table (1).

Table 1: Evaluation of TOE framework Environmental dimension

Author	Year	Environmental focus	Sector
Oliveira and Martins	2011	External environment	Multiple sectors
Baker	2011	Regulatory context, market, and competitive pressure	Multiple sectors
Awa et al.	2017	Regulatory context, partners and customers,	Multiple sectors
Modiba, and Kekwaletswe,	2020	External Task environment including regulatory context	Finance
Hao et al.	2020	Business environment	Logistics
Zhang et al.	2020	Green Manufacturing	Multiple sectors
Al Hadwer et al.	2021	External environment	Multiple sectors
Seshadrinathan, and Chandra	2021	External environment	Multiple sectors
Shukla and Shankar	2022	Firm structure, regulatory environment, competitors, and services providers	Manufacturing
Dora et al.	2022	Firm structure, regulatory environment, competitors, and services providers	Food supply chain

The review showed a paucity of studies providing a comprehensive perspective on the environmental dimension of the TOE framework. Therefore, this paper makes a valuable contribution by emphasising environmental sustainability in the environmental dimension of the TOE framework to fulfill the study's aim. Empirical studies have identified the critical success factors of digitalisation across different industries, but very few focused on 3PLs. Table (2) shows a sample of studies on logistics adopting the TOE framework, only one of which captured 3PLs."

Table (2): Enabling factors of digitalisation adoption in the Logistics industry analysed through the TOE framework.

Author	Technology	Organisation	Environment	Context/ Industry
Dora et al., 2022	Technology readiness, Relative advantage, Complexity, Compatible facilities, Sufficient privacy and security	The link between vision and strategy Top management support and ownership, Behavioral change management, Resources and competencies for AI adoption, AI provider commitment and support Organisation culture and environment	Demand volatility, Regulatory and compliance requirements, Ethics in data collection, Peer/competitor pressure, Institutional based trust	Food supply chain
Khan et al., 2022	Technological infrastructure	Knowledge Transfer Analytical capabilities Smart work environment Aligning the initiatives of Logistic 4.0 with organizational strategy Top management commitment and support Willingness to invest in Logistics 4.0 Training and Education	Trust and collaboration Research environment	General Logistics
Cichosz et al., 2022	Process standardization and data integration	Leadership Supportive Organizational culture Employee and partner engagement Aligning business and IT strategies training and skills development Agile transformation management	Leveraging internal and external (technological) knowledge	3PL logistics
Pfaff, 2022		Strategic agility		Supply chain

Therefore, this study contributes to the studies on 3PLs by applying the TOE Framework to identify success factors of digitalisation through a case study design.

3. Methodology

The literature review was driven by the topic of interest and a concept-centric approach using keywords such as digitalisation, sustainable logistics, 3PL, digitalisation success factors, and TOE framework (Webster and Watson, 2003). Major databases such as Scopus, Google Scholar, and Science Direct were employed to review the search results based on the keywords, titles, and abstracts to determine their suitability for the study. After collating a broad selection, the papers were further reviewed based on the publication dates (1998-2022) to avoid a concentration on dated research that excludes recent developments in the field.

Therefore, recent publications were prioritised to ensure that the state-of-the-art research is reported in this study supported by a secondary review of original publications.

Pratt et al., (2020)'s metaphor of research bricolage was employed to exercise the free agency of the researcher along with Parhi, et al., 2022's, approach to categorise the enabling factors identified from the review under the dimensions of the TOE framework, then validate them through an empirical case study to address the research gap. The case study approach followed Yin (2018)'s definition of an empirical inquiry investigating a phenomenon within its real-life context. The single case study investigates the enabling factors for successful sustainable digitalisation adoption to incorporate environmental sustainability in the 3PL sector, therefore the case firm was a 3PL. The exploratory case study design was conducted in an asset-based, freight forwarder 3PL in the UK whose strategy is to maximise digital technology to become the UK's Leader in sustainable delivery, therefore, the Sustainability team supported the data collection process. The 3PL has a parent company in Europe, so it operates from 84 EU locations using 10,000 vehicles to deliver over 260 million parcels a year. The enabling factors for digitalisation were validated with the case firm as discussed below.

4. Findings

The critical success factors of digitalisation from the literature were validated by the case study to demonstrate their impact on technology adoption for sustainable activities in a 3PL firm. The findings are captured in Figure (1) and explained below.

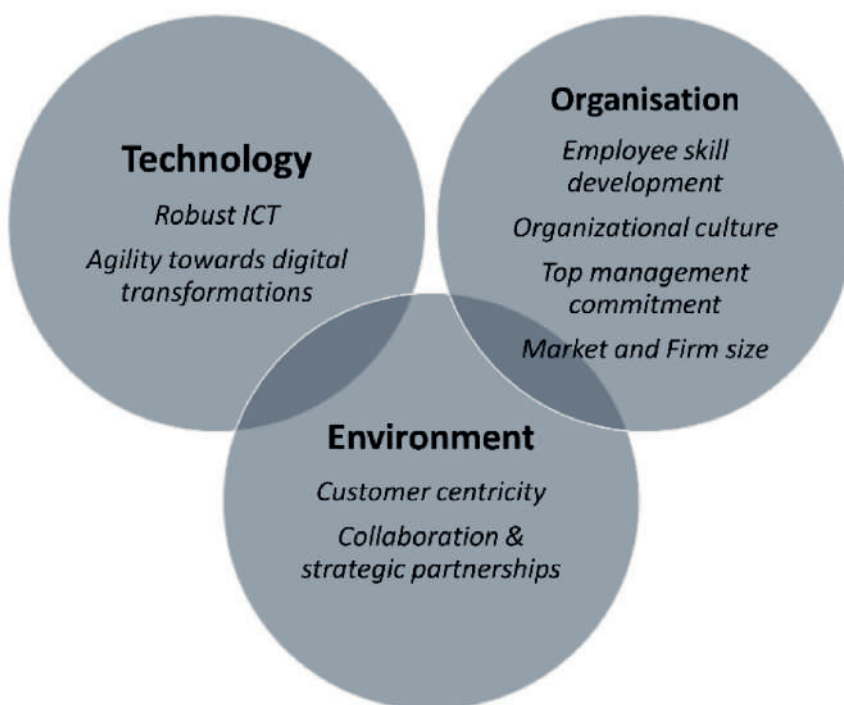


Figure 1: Enabling factors analysed through the TOE Framework.

Organisational Dimension

Market and Firm Size – The firm is part of a wider European 3PL group operating in several countries in Europe. While the wide geographical reach of the firm poses challenges associated with different legal frameworks, local cultures, and costs nevertheless, it has provided some opportunities to deploy different digitalisation initiatives in different markets with a sustainability focus. For example, ...in many European cities, more people live in apartments, ... delivery becomes very different, country by country. Smart lockers are famous in Estonia both for delivering over 90% of parcels to consumers and sending out parcels. The sustainability focus here has led to lower mileage for drivers and customers” which is environmentally friendly. Therefore, delivery is hastened, and customer satisfaction is improved. Also, the “London Microsite” delivers to people’s homes and flats, but it is the most expensive site per square metre because it is about a mile or two down the road from Westminster. Therefore, to control costs, pick-up lockers are situated in retail shops like Tesco’s local. A sustainability focus meant that e-bikes and e-vans were employed to reduce air pollution and congestion.

Top management commitment – This is a major driver of digital adoption as the Senior management has shown their commitment through the firm’s strategy to “...be the UK’s Leader in sustainable delivery”. This shows the firm’s commitment to delivering on the SDGs, especially those that are most impacted by their operations such as SDGs #8, #11, #13, and #17. With another part of their strategy aiming to “...use the best technology”, there must be alignment between the technology capabilities and sustainability mission for the present and future of the firm. As “...we have a clear strategy to implement published targets ... there’s no going back”.

Organizational culture – The culture is driven by the firm’s strategy as the respondent explained ... we launched our sustainability mission ... in 2020. This is now a major part of our strategy... by making people realise that it’s not just the sustainability team that’s gonna make this work. The journey to net zero is important for every single department... procurement, operations, delivery, etc. We’re making sure sustainability is central to everyone’s job role”. There is evidence of shared identity and responsibility toward employing digitalisation to deliver sustainable goals for the firm.

Employee skill development – The firm’s commitment to developing its people is captured in the final part of its strategy... to recruit, retain and develop the most customer-centric people”. The respondent explained ...“we provide our customers the best solutions to retain the best people because people make the organisation, you know, and by making sure that we have people right minded people to do that is extremely important”. They also have a “...people and talent team who are committed to ensuring equality and inclusion in the workforce” to support the engagement and development of staff. The social sustainability dimension is demonstrated here to value all employees through continuous development.

Environmental Dimension

Customer centricity – For this 3PL, the customer was not just a part of the environment for revenue generation purposes, but they were also a driver of sustainability, so customer centricity was a third part of their strategy. “... Some customers help us drive our strategy because they are fully aware of our contribution to them to reach their sustainability targets. And ... others are just on their journey and ... asking more macro-level questions instead of the micro-level. So, some customers... want to fully understand the accreditations, the measurements, and the reporting regarding sustainability...the momentum is gathering. You notice... the consumers have become...more aware of the impact of the purchase. How’s that piece of clothing made? ... how does it get to their front door? So, it’s throughout the chain”.

Collaboration & strategic partnerships – The firm highlighted potential risks associated with collaborations that could negatively impact their sustainability and digitalization journey. “There’s the positive of being linked to like-minded brands pushing decarbonization to achieve net zero emission target, with socio-environmental projects as well. But also, there’s an element of reputational risk that you could be linked to a business that is either doing nothing or doing even worse than nothing and causing a detrimental impact. But also... a lot of people want to make sure the ‘i’s are dotted and the ‘t’s are crossed... so, businesses are greenwashing and stating that they are doing XYZ, but they’re not. So, there are follow-ups... as part of due diligence on what we are saying to make sure it is true and right. Yeah... and we are also audited externally”.

Technological Dimension

Robust ICT – The firm emphasised the importance of digitalization capabilities “... from a business perspective, we must achieve efficiencies... it’s about making sure that we’re innovative and we push technology and digitalise. For example, optimisation of routes, ...so we’re not running more vehicles than we need to”. “We reduced UK emissions by 60,000 tonnes between 2021-2022 and aim for 78,000 tonnes reduction between 2022-2023 through digital tracking solutions. We have switched to more electric vehicles, so the next issue is congestion. Vehicles might be cleaner, but still emit particles obviously from tyres and brake discs. So, there’s still a responsibility from that angle”. The firm embraces a wide range of solutions e.g., cargo bicycles, urban bicycles, self-driving cars, etc., yet more effort is needed to achieve net zero sustainability.

Agility towards digital transformations – The firm’s agility towards digital adoption is captured as they aim “... to use the best technology available to achieve our sustainability ambition. Prior to my joining, the sustainability pillar was set along with others as the centre of everything that we do. We’re not cheap in the industry, because we invest a lot in the technology and the people, for example in the equipment that we use, so, it’s important for us to deliver the best service”. We’re on the journey to deliver 100,000 parcels a day using all-electric transport in London instead of diesel by the end of 2023.

5. Discussion and Conclusion

The enabling factors provide insights for effective digital adoption for delivering environmentally sustainable logistics operations and value capture in a sector that has been under-researched in the literature. While the empirical investigation did not introduce another enabling factor, it revealed the importance of top management’s commitment to sustainability in a transparent manner as the firm’s commitment was publicised in their corporate strategy and sustainability was the responsibility of every department and employee within the business. Hence, rather than having sustainability as a factor under the environmental dimension of the TOE framework only, the sustainability theme runs throughout all three dimensions. It also emphasised the importance of collaboration at different levels such as: (i) Collaboration within the industry with the competitors to joint problem solving which helps to share the responsibility of finding solutions to common issues such as sustainability. (ii) Collaboration outside the industry with technology providers. The acknowledgment of the need for greater effort to deliver and maintain sustainable operations emphasises the need for effective collaborations with technology providers. e.g., electric charging stations to support the operation of electric vehicles. Again, to avoid any connection with green-washing due diligence is required to audit the collaborators. In addition, the importance of customer centricity was emphasised as different countries have different cultures and different cities have different infrastructures which could aid or limit digitalisation adoption.

The need for firms to develop sustainable operations to achieve net zero by 2050 is a challenge that necessitates a comprehensive effort to identify the critical factors to ensure the successful adoption of digitalisation to address this need. The study employed a comprehensive literature review to identify a suitable theoretical framework and relevant factors validated through an in-depth qualitative case study in a 3PL to generate insights.

All factors are important for successful digitalisation adoption to support sustainable logistics operations as they help to perform a comprehensive assessment for implementation. Although some of the factors are interrelated e.g., the company strategy affected 5 factors directly, the challenge of achieving sustainability still exists. Therefore, a wider number of case studies will build on this exploratory study. In addition, to complement the strength of this qualitative study, a mixed-method approach can be employed for a more robust methodology. A closer consideration of the limitations of digitalisation on sustainability initiatives could form a strategic focus of future studies.

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EXPLORING CHALLENGES OF THE IMPLEMENTATION OF REVERSE LOGISTICS PRACTICES IN THE UK, CURRENT DISCOURSE: A PRELIMINARY STUDY

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Introduction

Reverse Logistics (RL) is developed following the need to move goods from customers back to suppliers and manufacturers (Bernon et al., 2018, Frei et al., 2020; Zhang et al., 2023). These goods can be reused, refurbished/repared, remanufactured, cannibalised, recycled, and disposed of (Bernon et al., 2018; Trivyza et al., 2022). Unlike forward logistics (FL), which is relatively stable, reverse logistics (RL) management is more complicated in terms of inconsistent forecasts; non-uniform product quality and packaging; price dependence on many factors; lack of standard accounting systems, less transparent and high cost of transactions, among other contextual factors (Rogers and Tibben-Lemke, 1999).

Despite the RL management challenges, there is a growing need globally to manage increasing waste management needs effectively/efficiently. It is suggested that the advancement of e-commerce has further aggravated RL challenges, as business organisations have resorted to using a lenient return policy as one of the critical competitive priorities (Frei et al., 2020; Zhang et al., 2023). According to Berno and Cullen (2007), return figure indicated a staggering £ 5.75 bn in the UK retail sector, representing 5-20% (Daugherty, Autry and Ellinger 2001), up to around 50% in some sectors (Rogers et al., 2002) in return rates. The rise of the internet and home shopping, along with the less restrictive return policies and shortened product life cycle, are captured as primary factors contributing to the rise in the product return rate phenomenon (Bernon and Cullen 2007).

These justify why the attitudes of business /public organisations and end-users towards adopting sustainable business practices have been under scrutiny in recent years (Frei 2020, 2023). Yet, circular economy (CE), closed-loop supply chain (CLSC), reverse exchange (RE), market exchange (ME) among other sustainability principles have not been mainstreamed by local RL operators in the UK/EU (Bernon et al., 2018, Frei et al., 2020; Zhang et al., 2023), possibly due to lack of awareness, leadership, evidence-based support tools that can inform cross-functional integration of RL. In this light, this article is developed on the premise that a lack of understanding of cross-sectoral action plans in national logistics markets such as the UK may impede sustainable RL practices, spur unhealthy business environment with the associated negative social and environmental impacts (Xie et al. 2016). Therefore, we identify and evaluate cross-sectoral RL practice and adoption challenges and identify ways forward that better integrate sustainability management goals on RL practices. In this light, we ask:

- What do we currently know about RL practice in the UK?
- What strategic considerations are needed to improve sustainable RL practices in the UK/Europe?

For this study, RL is defined as the role of logistics in product returns, source reduction, recycling, material substitution, reuse of materials, waste disposal and refurbishing, repair, and remanufacturing." (Stock 1998, p.20). Subsequent sections of this paper encompass research methodology, results/discussions, and conclusion/recommendations.

Methodology

Design

A thematic appraisal is undertaken in this literature review using a six-step process suggested by Leininger (1985) alongside open and magnitude coding strategies proposed by Stratus (1987).

Search method

Sampling

Electronic databases, including Scopus, Web of Science, Thomson Reuters, ABI/Inform, Emerald, Science Direct, MEDLINE, and IEEE Xplore, were searched using the following keywords: reverse logistics, circular economy, sustainability, product recovery, retail, product return, reverse logistics, reverse supply chain, return policy, return management, closed-loop supply chain and management, sustainability, industrial ecology, UK logistics market and their combinations to retrieve the reviewed papers. The search period covered is between 2013 to 2023.

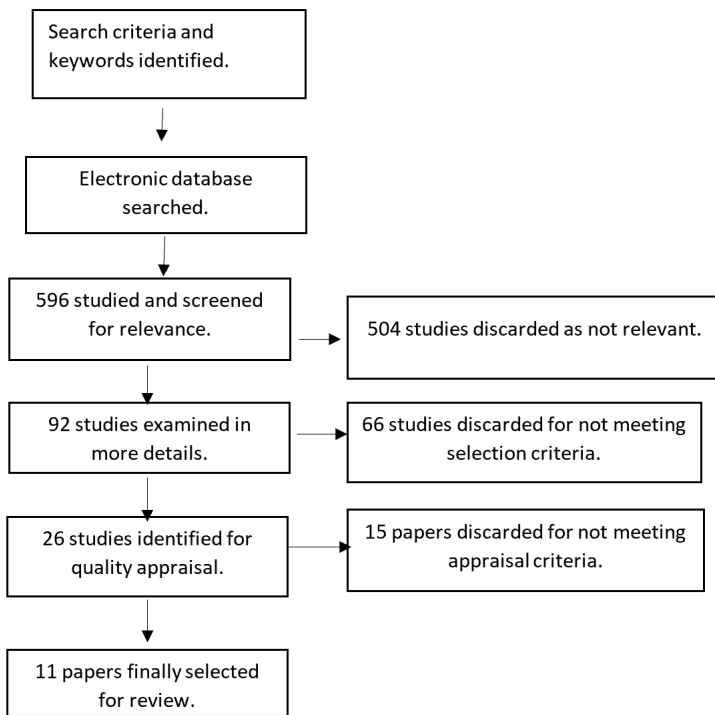


Figure 3: Literature Review Flowchart (Adapted: Pickles et al. 2009).

Inclusion and exclusion criteria

Inclusion criteria adopted for selecting the papers were guided by the scope of the study, empirical studies, studies undertaken in the UK and wider EU, published in the English Language, and published in peer-reviewed journals between 2013 and 2023. Papers excluded were based on study scope outside the reverse or related subjects, published earlier than 2013, and primary studies published in other languages. Relevant studies published in other major geographical regions, literature review publications, and/or publications before 2013 are only used for comparisons.

Search results

Initial searches identified 596, which were screened for appropriateness. The title and abstract of each paper were read to determine suitability; 504 were discarded as not being directly linked to the scope of the study, leaving 92 for a more detailed examination. These were examined to determine whether they met the inclusion criteria, and 26 were identified for appraisal and possible inclusion. While the co-authors conducted the initial searches, the principal author performed the selection process.

Study location

The included studies incorporated research into factors influencing and challenging RL implementations in the UK (n= 4), UK and other EU countries (n= 4), EU (n= 2), and UK and other geographical locations (n= 1).

Study design

Of the included studies, whilst four employed qualitative research approaches, one applied the quantitative method, and the rest (six) adopted mixed research methods.

Quality appraisal

Each study was selected and summarised according to year of publication, location, peer review process, and research process to ascertain whether the thoroughness of the study justified its inclusion. The appraisal process was undertaken cooperatively between the lead author and co-authors. Each author reviewed papers independently, and the results were compared. In circumstances where differences in the interpretation of results were observed, we achieved resolution through discussion.

Eight critical questions proposed by Schneider (2004) were used to assess the strengths and weaknesses of qualitative studies. Alternatively, the strengths and weaknesses of the quantitative papers' counterparts were evaluated using ten of Schneider's (2004) most relevant critical questions. While some studies that did not include sufficient detail about their research processes were excluded, others with clear and justifiable reasons supporting their study limitations were incorporated into the study.

Overall, papers that did not achieve two of three of Schneider's (2004) questions were not included. In line with quality appraisal, fifteen studies were removed (Chang et al., 2023; Md Shamimul et al., 2021; Sergey, 2021; Shuihua, 2016; Nageswara et al., 2019; Kenan and Christopher, 2022; Robert et al., 2023; Mehdi et al. 2021; Kamalakanta et al. 2023; Xi et al. 2016; Pedro and Pedro, 2015; Luai et al., 2023; Mukesh et al., 2023; Ipek et al. 2021; Abraham et al., 2023).

Analysis of research processes

Of the eleven papers studies in which the quantitative approach was employed, 16 different data collection instruments were used. The reliability and validity were reported. In three of the reviewed studies, the instrument used could be seen as a weakness. Concisely, most of the studies criticised their research instruments based on limited data, sample size, limited range of sampled companies, and geographical locations (Bernon et al., 2018; Xie et al., 2016; Trivyza et al., 2022; Larsen et al., 2018; Lapko et al., 2019). Others reveal that their research instruments lack generalisation in terms of mapping every aspect of strategic decisions around product recovery and interrelationships (Stindt et al., 2017; Lapko et al., 2019); limited context – reverse water logistics (Parry et al., 2016); limited scope (Frei et al., 2020; Zhang et al., 2023) This wide variety of instrument and differences in methods created difficulties in comparing results from each study and made direct comparison problematic.

Data abstraction and synthesis

The principal author performed manual coding and thematic analyses of the finding, marking keywords, phrases, and sections; identifying the meaning they communicate in relation to RL practices, challenges, and mitigations through identifying range of proposed initiatives and/or those already implemented in practice. Each paper was read several times, analysed and major themes extracted, and the frequency of prominent codes determined. These processes were informed by Robert and Taylor (2002), Leininger (1985), and Strauss (1987). This method involved a systematic analysis of the findings, groupings connected ideas, reducing connected ideas together and reducing the grouping as far as possible without losing their meaning. However, it is important to highlight that the analysis carried out did not capture implementation effectiveness in terms of the identified mitigation strategies. Also, an assessment of the outcomes of policy actions on each identified RL implementation barriers were not carried out. Inherently, these are potential areas for further research.

Results

What do we currently know about RL practice in the UK?

Following analysis of the reviewed studies, four major themes were identified, including manufacturing, retail, healthcare, and household utility. Each of the reviewed studies shows that RL operators across industries and sectors focus on achieving a variety of recovery options: reuse, repair, refurbish, remanufacture, cannibalise, recycle, and dispose, as demonstrated in detail below:

Theme 1 – Manufacturing Industry

Manufacturing was among the most commonly occurring theme and was identified in 36.36% (n=4) of the studies. The associated sub-themes include automotive/aeronautic (n=1, 25%) (Trivyza et al., 2022), Original Equipment Manufacturing (OEM) (n=2, 50%) (Larsen et al., 2018; Stindt et al., 2017), and manufacturing-green energy technologies photovoltaic panels and wind turbine (n=1, 25%) (Lapko et al., 2019). Whilst Trivyza et al. (2022) utilises reverse supply chain optimisation model to explore how composite materials are commonly used in engineering application to replace the conventional materials in UK's Automotive/Aeronautic, Larsen et al. (2018) employ seven case studies of OEM in Denmark to highlight how the reverse supply chain contributes to a firm's competitiveness via its applications at strategic, tactical, and operational levels; Lapko et al. (2019) utilise single case study instrument to examine how closed-loop supply chain has been used to improved cascading of green energy technologies (e.g., photovoltaic panels and wind turbine) in Europe; Stindt et al. (2017) adopt Mixed method study to investigate the attractiveness of product recovery among OEM firms in the UK and Germany.

For the OEM operators in Denmark, reverse supply chain contributes to a firm's competitiveness via its applications at strategic, tactical, and operational levels (Larsen et al. 2018). This explicitly highlights the current urgency of integrating RSC in the strategic positioning of OEMs- even though all the sampled firms adopt different strategies (competitive priorities) to attain their desired competitive advantages. Larsen et al. (2018) study demonstrates the interplay among value creation mechanisms, enabling environment, and degree of the alignment between value creation mechanisms and competitive strategies. Similarly, Stindt et al. (2017) reveal that despite some progress (in addressing the RL integration in competitive positioning of firms), sustainable RL practices are not well integrated into the UK and German local business operations, at least product take-back and recovery initiatives (Maslennikova and Foley 2000).

Further, Lapko et al. (2019) reveal that while there is no anticipation of any future improvement in the frequency of green energy technologies photovoltaic (PV) recycling in Europe due to its long product lifecycle, Lapko et al. (2019) indicate that there is a lack of infrastructure and insufficient capacities (collection system) to support product return management. The RL concerns referred to in this article refer to the underutilisation of capacity in the broader sense, as PV recycling activities comprise about 10% of the overall operational activities. Such operational challenges could have huge implications for the price instability of critical raw materials (CRMs), low market demand for recycled materials, and low business opportunity for recycling material.

Theme 2 – Retail Industry

Like manufacturing industry, four studies (36.36%) emerged from the retail industry, focusing on CE (Bernon et al. 2018), product return management (Saarijärvi et al., 2017). and sustainable reverse supply chain management (Zhang et al., 2023; Frei et al., 2020). The focus on CE was broadened following the increasing interest in maximising the circulation and minimising the content that could end up in landfill or incineration (Bernon et al., 2018). This initiative formed the basis for integrating RL practices into CE, facilitating management of product returns, end-of-life (EoL) procession and product recovery-repairs, reuse, refurbishment, remanufacturing, and recycling. However, to date, this is yet to be implemented in the UK's logistics market (Bernon et al et al. 2018). The desire for the implementation of these key principles gave rise to other initiatives, including bottom-line management, especially when return management is a critical element (Stock 1998 and Mason 2002). This development has a variety of overarching implications in the modern market systems due to the globalisation of e-commerce, online purchase and associated return management challenges which have become increasingly critical in the modern retail industry (Bernon et al., 2018; Frei et al. 2020; Zhang et al., 2023; Saarijärvi et al. 2017).

Currently, product returns in the retail industry are prominently wasteful with considerable negative environmental impacts (Zhang et al., 2023; Frei et al., 2020). For example, packaging and processing, and the returned item is often discarded. Product return management challenges are exacerbated by the recent flourishing of e-commerce. While embracing ease of accessibility of goods and services and low cost of operations associated with online sales, there is a significant gap regarding the management of product returns in a more environmentally sustainable manner (Zhang et al., 2023; Frei et al., 2020). This development supports the notion that multichannel retailers (including the fashion industry) in the UK, EU, and North America lack a comprehensive approach to addressing the environmental impact of product return (Zhang et al., 2023; Frei et al., 2020). Following this development, Saarijärvi et al. (2017). identified ten categories of online returning behaviour and links with when the decision to return ordered items emerge.

Theme three – Healthcare

Whist Xie et al. (2016) explores reverse exchange systems used for medical devices in the UK National Health Service (NHS), Papalexi et al. (2022) examine factors influencing pharmaceutical supply chains and management innovation in the UK and Greece. They collectively represent 18.2% of the sample studies using mixed research methods. Reverse exchange (RE) of medical devices can be defined as occurring when products are returned to the source for exchange or final recovery due to product replacement (based on patients' needs changing), product maintenance (the functionality of the product parts needs to be checked or repaired) or obsolescence (product reaches its natural end of life).

A range of approaches for implementing RE of medical devices was identified, including adopting a closed-loop supply chain, e-procurement, and e-supply chain management techniques among three NHS Trusts in Greater London and Essex, England. Concisely, NHS Trust in Greater London focuses on the RE of infusion pumps used in the Oncology Department, using e-procurement and e-supply chain management tools to collaboratively identify the users who borrowed the devices and contact them via email or telephone. Collections and reprocessing are arranged by the Medical Equipment Libraries (MEL). Overall, there are four types of RE of infusion pumps between the Oncology Department and MEL, including manufacture recall, a faulty device, regular maintenance, and end-of-life returns.

Similarly, the innovative pharmaceutical supply chain (PSC) initiative reflects the awareness to improve service provisioning in Hospitals and Community Centres, especially regarding the delivery processes of pharmaceutical products (Papalexi et al., 2022). Indeed, how the pharmaceutical companies in the UK and Greece adapt to the high-volume demand of pharmaceutical supplies is a pressing supply chain management issue as they are currently using moderate innovations (Papalexi et al., 2022). Although PSCs are supposed to account for both forwards and reverse logistics management, they are currently forward supply chain oriented and concerned mainly about delivery in terms of quality (product and service quality), visibility (knowledge and information sharing), speed (response to customers and suppliers need), and cost minimisation (Papalexi et al., 2022). As such, there are limited wider efforts to adopt lean/reverse logistics approaches among the 130 sampled firms in the study locations. Inherently, the adoption of lean RL approaches could have helped the local Pharmacies to provide greater value to customers (competitive advantage) through incorporation of sustainable RL management practices, commitment of relevant manpower and infrastructural capacities (Papalexi et al., 2022).

While RL adaptation practices were found to be less visible in PSC, enthusiasm and engagement were significantly higher in the adoption of RE and lean logistics (e.g., just-in-time deliveries) approaches, highlighting the acceptability of innovative practices in the healthcare sector (Timmons et al., 2014). To drive conversations on RL implementations, there is a need to adopt CE values, closed-loop supply chain principles, and e-inventory approaches to promote the standardisation of RL processes through the support of relevant, intelligent solutions (Shafique et al., 2019). This seems appropriate given the need for developing compatible and integrated IT systems to facilitate capturing, storage, and manipulation of large volumes of data related to medical device exchanges and the distribution/use of pharmaceutical products (Raghupathi and Raghupathi, 2014).

Theme 4 – Household Utility

This theme refers to the household utility of products and implications for the operationalisation of reverse supply chains using IoT (Parry et al., 2016). The study adopts multiple case study research methods in the UK. Much speculation about how the improvement of reverse supply chain requires accurate and timely information about the pattern of consumers encompasses a variety of mechanisms. With IoT has been used to track consumers' use of products at home settings, the

extent of applications of RL practices are far fetching in the domestic product recycles. However, the ways to generate and access use-visibility data in home settings are in their infancy (Parry et al. 2016).

A synthesis of the six case examples shows that IoT devices can be used to track consumers use processes of goods, services and resources in their homes. The reverse supply chain implications of this outcome include that consumer's perception of resource use can significantly differ from the actual use. For example, the sharing of Megan's towel without her knowledge and the difference between the time spent in the shower versus her assessment all indicate the reverse supply chain situation in the home setting. Second, use activities that are linked can follow a discrete pattern, meaning that some use activities are moderators for other use operations. For example, "when Megan goes running (moderator), she uses twice as much shower gel and water." (Parry et al., 2016,). Third, utilisation functions in the homes are disproportionately shared by the residents. As such, when the generated data represent the individual in the shared spaces, attribution of data to an individual becomes more complex compared to when accumulating data from personal devices, such as smartphone applications (Parry et al., 2016).

RQ2: What strategic considerations are needed to improve sustainable RL practices in the UK/Europe?

A range of factors may explain the lack of cross-thematic integration of RL across the identified industries in the UK comprising lack of adequate leadership and visioning, inappropriate infrastructural and human capacity, and limited regulation compliance, among others. The RL being a cross-thematic function is governed by the innovative capabilities of concerned firms. It relies on the combination of institutional (legislative), organisational, and market expertise to develop a regional and collaborative RL framework. Governance (legislation) and funding arrangement from relevant external institutions can enhance opportunities for wider local-level consultations on how to embed sustainability values and principles in RL practices. For example, the literature reports limited integration of sustainability values with RL practices in the UK's retail sector. This indicates that action preparedness based on local scoping, training, and awareness of how to transform sustainable business principles into business opportunities (Bernon et al. 2018; Trivyza et al., 2022; Larsen et al., 2018; Lakpo et al., 2019; Stindt et al., 2017).

Constraints, including lack of effective leadership and vision, infrastructure (ICT), manpower, market-related (the effect of the secondary market, lack of interest in remanufactured products), inconsistent legislation and sustainable business practice, lack of sufficient alignment between reverse supply chain and firms' competitive advantage, dearth of EoL material catchment area, spanning multiple countries, and absence of multi-product recycling solutions – can encourage cross-thematic incoherence in the application of RL values (Bernon et al. 2018; Trivyza et al., 2022; Larsen et al., 2018; Lakpo et al., 2019; Stindt et al., 2017). Similarly, lack of collaboration among relevant stakeholders can limit the scope for comprehensive RL practice in the UK's health sector and consumers' returning behaviours (Papalexi et al., 2022, Xie et al., 2016, Saarijärvi et al., 2017).

All the RL concepts reviewed here explicitly suggest that significant investment is needed to reverse the current anti-environment and social trends in RL in the UK. However, environmental, and social stewardship that promotes the long-term adaption of sustainable RL practices is required to make meaningful investments in the UK/EU in the long run. The themes (manufacturing, retail, health, and household) emphasised in this analysis represent both a challenge and an opportunity for sustainable developments across the industries/ sectors sampled in this study.

Conclusions and recommendations

Indeed, some form of effective, sustainable RL values exist which guarantee future improvements in practice; however, the scopes of the existing practice should be revisited, encompassing knowledge restriction of the environmental strategies (lack of awareness and priority and difficulties in measuring the environmental effects) and profit-oriented trade-off limiting environmental friendly practice (the complexity of product returns and decision making and choosing the right path for each returned product) (Zhang et al., 2023). Sustainability-sensitive organisational leadership is vital here (accounting for value preservation of returned items and collaboration with the third-party optimising return approach), so also are proactive policies (early-stage return prevention and indirect benefits of other effective return management strategies) (Zhang et al., 2023).

The following are proposed as ways in which new sustainable RL thinking (such as the principles inherent in the change management initiative) can be pursued: (i) Promote the integration of sustainable RL principles and values into organisational strategic vision and delivery through portfolio initiatives, programs, and projects. (ii) Promote knowledge sharing. The local industry stakeholders need to develop their leadership potential; understand the laws and regulations guiding sustainable business practices and sustainability management strategies. Investment in professional development, research, and awareness creation are essential. (iii) Early and vigorously pursue sustainable business opportunities to facilitate the sustenance of sustainable RL practice. (iv) Ensure that local intervention approaches are collaborative. Proactive and people-centred initiatives should be pursued in agreement with the do-no-harm values. Sustainable RL, when fully in place, can serve as a means to an end, where the end is to improve CE, closed-loop supply chain, RSC, and RE through the integration of RE principles into the diverse industry/sector concepts where applicable. This outcome-oriented perspective can foster necessary political and organisational development in the UK/EU RL market.

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A WICKED AND COMPLEX PROBLEM ANALYSIS FRAMEWORK FOR ELECTRICAL MACHINE SUPPLY CHAIN SUSTAINABILITY

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Purpose: Due to the interaction of various stakeholders across supply chains, implementing changes for achieving sustainability is a challenge with great complexity. Because of the complexity of supply chain sustainability, it can be classified as a wicked problem, which are often characterised by their interconnectedness and dedicated solving approach. As part of this research a framework on wicked problems from the literature, to classify and solve these problems, is applied to a new area and refined. The purpose of this research is to explore the extent to which a structured wicked and complex problem framework can be useful in characterising challenges related to decarbonisation and sustainability.

Research Approach: Most practitioners would not consider supply chain management as a wicked problem. When sustainability and the goal of net zero is applied to supply chain management a new set of challenges arise though. Through the review of literature in the field of supply chain sustainability and wicked problems, an established framework has been adapted and refined. To test the robustness of the framework and refine it, it has undergone an analysis using a report focusing on the actions necessary for achieving net zero by 2050 in the UK. These actions come from the decomposing of the general goal of net zero into smaller, manageable ones. Electrification is a key element on the pathway to net zero for the supply chain. To achieve the 2050 net zero target, a roadmap can be used as a form of decomposition and communication of the net zero problem. The refined framework is applied in the analysis of an electrical machines roadmap for 2050. This includes the requirements of materials supply for a 2050 demand for electrical machines. The questions forming the backbone of the research are: 1) Does the process of decomposing complex problems through approaches such as a roadmap change the nature of wicked problems? 2) How does a roadmap impact the wickedness of the electrification problem?

Findings and Originality: The research indicates that the application of the framework and the decomposition of wicked problems, such as the demand of electrical machines for a net zero world by 2050, helps in the categorisation and approaching of these. There is originality in this framework approach in the application for supply chain problems as well as the decomposition of problems.

Research Impact: The framework can aid in the categorisation of problems relating to decarbonisation and sustainability and depending on this categorisation it can propose approaches for these problems. It will also reveal the degree of decomposition necessary for making problems in the field approachable to reach a solution for the overall problem.

Practical Impact: When implemented, the framework can help managers and leaders in the field of supply chain sustainability to categorise problems and provide approaches for these problems to solve them. It will be helpful to get closer to the goal of decarbonisation and net zero.

Keywords: Supply Chains, Net Zero, Wicked Problems, Complex Problems, Structured Framework

Introduction

The target of achieving Net Zero by 2050 has led to a wide range of challenges being identified which need to be addressed well in advance of the target date. One area which can have a major impact on our ability to reach net zero as well as playing a key role in the global economy is that of supply chains. Several approaches have been discussed in the literature with regards to supply chain sustainability including the wicked problems concept. To classify these problems according to

their complexity and provide an understanding of where the complexity of the problems stems from, a framework from the literature is adapted which also points towards solutions for the problems. This framework is structured and has four steps for positioning problems. It is analysed and tested for its applicability using the absolute zero report (Allwood et al., 2019) from the UKRI funded UK FIRES research programme, which provides an overview of 13 actions for achieving net zero which all have major supply chain implications, and provides a basis for refining the framework.

Following this, the framework is used in the analysis for a more specific technological area around electrical machines to assess whether the framework is still appropriate beyond a general application. Electrification plays a key part in the road to Net Zero. Hence, the refined framework is used in the analysis of a roadmap (Ward et al., 2023) from the Future Electrical Machines Manufacturing (FEMM) Hub focusing on the development requirements for Electrical Machines for 2050. In the following the relevant literature on this will be discussed, followed by outlining the challenge proposed by this. Subsequently the framework will be introduced as well as the analysis using the absolute zero report and the FEMM Hub roadmap before concluding.

Literature Review

Sustainable Supply Chain Management

For sustainable supply chain management, the triple bottom line of sustainability plays a key role (Carter and Easton, 2011). It incorporates three aspects to sustainability: environmental, economic and social. General research into sustainability is towards the top of the research agenda, as companies are looking to be sustainable in the long-term (Touboulic and Walker, 2015). The economic perspective is prioritised as the most important to firms due to being able to determine the success and competitiveness of companies (Abbasi and Nilsson, 2012; Winter and Knemeyer, 2013). The social and environmental factors are not so much in focus whilst they are just as important to operationalise sustainable supply chain practices (Abbasi and Nilsson, 2012; Winter and Knemeyer, 2013; Sauer and Seuring, 2018). It can be argued that these are required for driving acceptance and desire for implementation of supply chain sustainability. This could be a key to the challenges for achieving the actions in the absolute zero report by UK FIRES.

Challenges for Sustainable Supply Chain Management

Developing sustainable supply chains is not well defined which is a major challenge already. Abbasi and Nilsson (2012) have identified several supply chain management challenges reflected in sustainable supply chain management: costs, complexity, operationalisation, mindset and cultural changes and uncertainties. Uncertainty is a factor that can prohibit change. The fear to change a system that has worked well in the past and the interpretation of sustainable supply chain operationalisation can hinder the implementation of sustainable supply chain practices due to the uncertainty of the outcome (Abbasi and Nilsson, 2012). However, as the Covid-19 Pandemic has shown, when being pushed to change this running system, it is possible to adopt changes. This was a non-voluntary change though. Sauer and Seuring (2018) suggest that implementing multi-tier sustainable supply chain practices could reduce this uncertainty. Additionally, developing policies can help companies to guide their focus in sustainable supply chain practices to somewhat reduce uncertainties. However, they have been mainly focused on transport (Abbasi and Nilsson, 2012).

Furthermore, the social aspect can provide challenges for sustainable supply chain management. Organisational culture and mindset have a key impact on the implementation of sustainable supply chain practices (Abbasi and Nilsson, 2012). It is important that the views of employees are also incorporated in decisions (Touboulic and Walker, 2015). Carter and Easton (2011) suggested that a lack of transparency could prohibit the implementation of logistics social responsibility and management plays a role in this (Winter and Knemeyer, 2013). Abbasi and Nilsson (2012) argued that there is a challenge for managers to put sustainable and environmental management into the everyday decisions of businesses and that for this to happen managers need to adapt and change their way of thinking. Top management engagement is important for employees to take on the responsibility to put into practice and live the sustainability measures developed (Abbasi and Nilsson, 2012; Esfahbodi et al., 2017). Furthermore, it has been found that collaboration across the supply chain is key to achieving real impact in the change towards sustainable supply chain management, as there is a potential to reduce emissions through collaboration in closed loop supply chains for example (Abbasi and Nilsson, 2012). The problem is not well defined, as a result specific technological solutions are not universally applicable with a large part of the difficulty stemming from political complexity. Therefore, supply chain sustainability can be described as a wicked problem.

The Role of Collaboration

The need for collaboration in supply chain sustainability makes it politically challenging and shows the interconnectedness, as imposing a change from the top end of the supply chain is not well received overall. According to Vachon and Klassen (2008), collaboration with actors across the supply chain can positively affect environmental and manufacturing performance of a firm. Esfahbodi et al. (2017) also suggested that the interaction between suppliers could impact sustainable supply chain management implementation. Managers are increasingly aware that the social and environmental responsibilities of a company involve various actors across the supply chain. Therefore, it is important to look for ways to coordinate sustainability aims across supply chain partners as well as collaborating with key supply chain actors (Winter and Knemeyer, 2013). Collaboration and coordination are especially important across the supply chain, as it may help different supply chain members to work towards a standard set of goals rather than having differing views and interpretations (Winter and Knemeyer, 2013). Enablers of this can be information sharing to create more transparency across the supply chain, and integrating processes (Reefke and Sundaram, 2017). Wicked problems is a concept where collaboration is required to solve complex issues.

Wicked Problems

Rittel and Webber (1973) set the research basis for wicked problems through defining a set of primary characteristics. Wicked problems are often characterised as complex problems that are interconnected and involve different stakeholders (Dentoni and Bitzer, 2015; Head and Alford, 2015). It is also argued that problems which are seemingly difficult to solve are labelled as wicked problems to justify not attempting to solve them (Peters, 2017). Examples of wicked problems are ones related to sustainability, poverty and inequality (Dentoni and Bitzer, 2015; Peters, 2017). Another concept like that of wicked problems is super-wicked problems, under which Levin et al. (2012) classify global environmental issues, such as climate change. The characteristics of wicked and super-wicked problems vary. There are four additional characteristics unique to super-wicked problems: 1) there is a time restriction, 2) the problems that are to be solved are in fact caused by those that intend to solve them, 3) there is little to no central governance that addresses the issues, and 4) the problem solving is shifted to the future, rather than taking responsibility and acting now (Levin et al., 2012). In the following the concept of wicked problems will be focused on, however the ideas are also applicable to super-wicked problems, such as sustainable supply chain management.

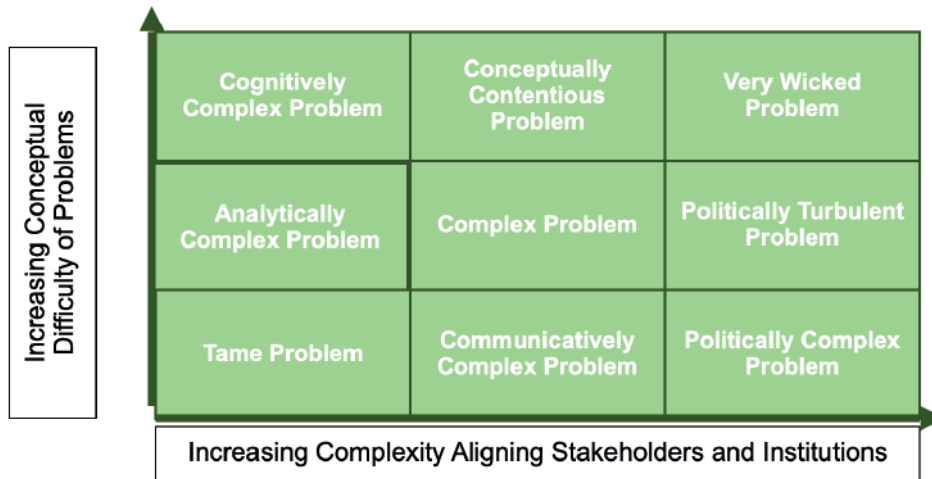
The extant literature suggests several ways for attempting to solve wicked problems. For example, rather than individuals approaching wicked problems, collaboration between different stakeholders should be facilitated and form the basis of any approach to a wicked problem (Weber and Khademian, 2008). This could be explained by stakeholders having experiences personal to them and having access to different pools of resources which will inevitably result in diverse ways of approaching a problem (Dentoni and Bitzer, 2015). Hence, networks have been claimed to be better at solving wicked problems as they attempt to resolve issues in a less centralized way, which somewhat enables flexibility (Peters, 2017). The nature of wicked problems suggests that finding the one solution is not possible and that rather the attempted definition of the problem may prompt towards a possible solution (Head and Alford, 2015). Therefore, this aspect of flexibility is especially important to adjust the way of action when unexpected incidents come up during the process (Weber and Khademian, 2008). Furthermore, one of the difficulties that stakeholders may be confronted with when attempting to solve problems collaboratively is the flow and exchange of information across different stakeholders, indicating that stakeholder engagement is vital throughout the process (Weber and Khademian, 2008). This problem of information sharing is reflected in supply chain sustainability, as suggested by Reefke and Sundaram (2017).

Research Work

Introducing the Analysis Framework

Through the review of literature in the field of supply chain sustainability and wicked problems, a framework has been adapted and compiled. The work from Alford and Head (2017) and Roth and Senge (1996) have been the main source of information for the framework. Alford and Head (2017) have set out a typology and contingency framework for positioning problems on a scale from Tame to Very Wicked. Ward and Godsell (2019) have worked with a similar framework focused on supply chains, whilst that of Alford and Head (2017) is more generic. These two frameworks represent a structured approach of dealing with wicked problems and are therefore appropriate to consider with respect to supply chains. The Alford and Head (2017) typology focuses on two aspects to be considered with problems; the problem itself and the stakeholders involved with the problem. These two aspects are divided into three dimensions, as shown in Figure 1 below.

For the problem itself, shown on the y axis, the three dimensions are: 1) the problem is clear and the solution is clear, 2) the problem is known, however the solution is unknown, 3) the problem nor the solution are known. For the stakeholders, shown on the x axis, the three dimensions are: 1) knowledge and interest are shared between stakeholders, 2) knowledge is fragmented across stakeholders making it difficult to have a holistic overview, however stakeholders agree on the problem and possible solutions, 3) knowledge and interests are fragmented across stakeholders.



Placing these dimensions together on a diagram, there are nine outcomes, each describing a degree of wickedness of a problem. For both aspects, the first dimension points towards a tamer problem and as it increases to the third dimension, the problem becomes more complex and wicked.

Framework Positioning Steps

To position problems onto the framework, a process of four steps has been developed using the work of Alford and Head (2017) and Roth and Senge (1996) as a basis. The first step of positioning follows initial judgement based on where problems seem to fit. The second step is used as a form of confirmation of the position considering the two aspects of problems: the problem itself and the stakeholders involved. Various questions help to determine the problem complexity and the stakeholder difficulty of problems and therefore the position on the framework. The third step focuses on defining the scale and the importance of the problems. The points in question for the third step are: Structural Complexity, Knowability, Knowledge Fragmentation, Knowledge Framing, Interest Differentiation and Power distribution. These factors affect the scale of the problem and indicate that if more of them apply to a problem, the wickedness of it increases. They can also be divided into the two aspects of problems. The fourth step is used to check the position of problems relative to one another and the two aspects on the axes. There are a set of questions adapted from the work of Roth and Senge (1996) including further considerations to help with the positioning of problems.

Framework Review Using Absolute Zero Report for Analysis

To test the adapted framework the UK FIRES absolute zero report is used as an example. In this report, the focus is on the actions necessary to reach net zero emissions by 2050. Through a critical analysis, the different actions suggested are used as problems to map onto the framework, going through the four positioning steps as discussed. As the report focuses on actions necessary for achieving absolute zero in the UK, the analysis also takes a main UK focus. It will uncover whether breaking a complex problem into smaller sub-problems will help to overcome the overall problem.

To approach the complex problem of net zero by 2050, the absolute zero report proposes several actions which focus on smaller problems on the path to net zero that should help reach this goal. The main areas of focus of these actions are outlined below (Allwood et al., 2019):

1. Road Vehicles, 2. Rail, 3. Flying, 4. Shipping, 5. Heating, 6. Appliances, 7. Food, 8. Mining material sourcing, 9. Materials Production, 10. Construction, 11. Manufacturing, 12. Electricity, 13. Fossil Fuels

The analysis of the actions showed that they do not provide a complete solution, but rather just a start to the areas that need to be focused on for net zero. In other words, the general problem of net zero has been decomposed by one degree to these 13 actions. In this case, the decomposing by one degree revealed some issues. For road vehicles, absolute zero suggests to phase out petrol and diesel engines and move towards electrifying vehicles compatible with net zero. There are huge logistical, cultural and supply chain challenges to overcome, especially when applying on a global scale, to make the switch to electric vehicles. For example, there will be a switch in demand for materials specific to these new types of vehicles and a supply of materials to build the vehicles must be assured. Furthermore, having an infrastructure in place for vehicle charging is also vital, this includes the necessary supply of electricity to complete the charging. These examples can be described as secondary problems to the initial problem of road vehicles raised in the report. Throughout the analysis of the 13 actions, it was found that they all have secondary problems associated with them. Some of the actions are affected by secondary problems that are more severe than others and have a higher impact.

In terms of the framework set up and position steps, the analysis of the absolute zero report showed that some amendments to the framework can be made to make it more applicable. Following the analysis of the report using the framework, it was found that the questions raised under the different framework steps were in part overlapping and some did not add further depth to the analysis. As a result, it was possible to refine and condense the framework for further application.

Electrification for Net Zero and the Future Electrical Machines Manufacturing Hub

Electrification plays a major role in the path to net zero. Many of the advancements perceived as compatible with net zero rely on electrification of processes or products. To enable developments in electrification, research in the field is vital. The FEMM Hub plays a central role in this for the electrification in the UK. It is a research programme putting UK Manufacturing in the lead of electrification (Ward et al., 2023).

To consider the advancements for electrical machines necessary for a net zero world by 2050, the FEMM Hub developed a technology roadmap to act as a form of communication for this. There are a few key points from the roadmap; identifying the needs for future electrical machines, supply chain responses, general improvement factors, factors future electrical machines need to have and factors for manufacturing electrical machines as well as further advancements necessary in the roadmap environment for electrical machines. The FEMM Hub roadmap seems to decompose these points in several stages to make them more approachable and provide dedicated areas of action. These are the actions used in the analysis with the refined framework. For the supply chain responses, a set of four responses have been identified that need to be provided for an electrical machines supply chain (taken directly from Ward et al., 2023):

1. Step change in production volume for high performance applications
2. Flexibility in physical supply chains and in the product development process
3. New circular economy provisions to support material availability under increased volume
4. and, especially to enable market disruption, substantial cost reduction.

When starting the analysis it has been identified that the further degrees of decomposition makes the overall problem more approachable due to providing more detailed points of action. There is less leeway for interpretation of how the actions may be approached. The actions are clearly defined along with the solutions for them. With regards to the supply chain side, there are some major weaknesses of the roadmap. This is an area that needs further development.

Discussion

A key difference between the actions in the absolute zero report and the points for electrical machines in the roadmap is the applicability and detail. This can be explained by the difference in the degree of decomposition. Whilst absolute zero attempts to provide a broad holistic overview of all actions necessary to meet net zero by decomposing this by one step, without going into detail of the exact processes needed to achieve these actions, the roadmap focuses more specifically on electrical machines and provides further details and degrees of decomposition on the points helping to move towards electrical machines for net zero.

The absolute zero report and the FEMM Hub roadmap both have a different purpose behind them and both have weaknesses to them. Absolute zero is written to be provocative, spark people to think more creatively on net zero and explore the possibilities of working with current levels of technology. Some of the points raised are not discussed outside of absolute zero, such as all airports in the UK closing, with flying to stop completely and shipping to stop completely too. Work is going into making those sectors more sustainable rather than completely discarding them. The roadmap on the other hand is aimed at giving a unified direction to disparate and technical engineering research fields. One of the main limitations is that given the limited information available it was not possible to quantify current material demand, especially for rare earth materials, which is a key topic for the move towards net zero and electrical machines (Ward et al., 2023). This could be overcome with further collaboration across industry and academia in the future. Overall, both the report and the roadmap are not created with the aim of decomposition for net zero, which indicates that this decomposition is unlikely to happen naturally and implies a strategic approach.

With regards to the framework, in the analysis of absolute zero some of the questions were not so intuitive to answer due to the abstractness of the actions proposed. Initially it was almost impossible to analyse absolute zero without going into detail of the secondary problems associated with the 13 actions.

In contrast to the absolute zero report, where the general net zero goal was decomposed by one degree to develop 13 actions, the FEMM Hub roadmap uses some points necessary for the electrical machines for 2050 in general and seems to decompose them further along, providing more detail in the actions necessary for approaching the overall problem. This makes electrical machines for 2050 more approachable. However, the FEMM Hub roadmap does not provide an exhaustive overview of the developments necessary for electrical machines by 2050. It acknowledges the need for continuous improvement of the roadmap with time due to possible advancements that are not able to be included or discussed momentarily.

Conclusion

In conclusion, the analysis on the absolute zero report and the FEMM Hub roadmap using the framework adapted from the literature provided different outcomes and indicated areas where further work is necessary. The FEMM Hub roadmap provides a more in-depth explanation of achieving the different suggestions put forward by going through what could be defined as further stages to decompose the general action of manufacturing electrical machines for 2050. Using the framework for analysis it was found it helps to approach electrical machines development when there is more detail on the actions necessary for the goal. This was different for the actions in the absolute zero report, which were sometimes rather vague. The framework discussed provides a good tool for analysis of the problems around net zero and sustainability as found in the research. Overall problems such as net zero must be decomposed to be progressed. This decomposition must be effectuated correctly for the overall system to retain the primary challenge but still make it more addressable.

Further work in the area can provide more robustness in the findings. As discussed previously, especially with regards to the supply chain side of electrical machines and the sustainability, further work is necessary. Additionally, the framework could profit from being applied to further areas also with an international focus, as both the absolute zero report and the FEMM Hub roadmap take a UK focus.

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DELIVERY EFFICIENCY AND FLEXIBILITY THROUGH LOGISTICS NETWORK DESIGN

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1. Introduction

Logistics and supply chain management are crucial to the success of companies operating in today's fast-paced and intensely competitive market. This circumstance highlights the need for adaptability in logistics systems (Matthyssens, et al. 2005). Designing and managing effective logistics networks can have a substantial effect on a company's operations, customer satisfaction, and bottom line. One of the most important applications of commodity network design is the design of logistics networks that connect suppliers, manufacturing plants, warehouses, distribution centres, and customers in order to manage the acquisition of raw materials and components, their transformation into finished goods, and their delivery to customers (Cordeau, et al., 2021). The design of logistics networks has a significant impact on logistics management. It often includes aspects like as supply nodes, warehouse hub nodes, and demand nodes, and it has a direct impact on the cost and efficiency of logistics operations. In recent years, there has been a growing emphasis on delivery efficiency and flexibility in the design of logistics networks. Delivery flexibility comprises the ability to change delivery dates and fulfill rush and special orders (Beamon, 1999; Slack, 2005), whereas delivery flexibility refers to the capacity to respond to shifting client requirements and market conditions. In an era of escalating customer demands and fast changing supply chain dynamics, these two criteria are essential for organizations to remain competitive. Over the years, technological advancements have helped companies to increase their delivery efficiency and flexibility, hence enhancing the entire logistics network design (Mangiaracina, et al., 2019). There is still a need for empirical study to further understand the influence of delivery efficiency and flexibility on logistics network architecture and, ultimately, customer happiness, notwithstanding the advances gained. Specifically, there is a need to investigate how delivery efficiency and flexibility influence various aspects of logistics network design, such as transportation mode selection, inventory placement, facility layout, and distribution network configuration, and to assess the relationship between delivery efficiency, flexibility, and customer satisfaction. Furthermore, the literature on delivery efficiency in achieving Customer Satisfaction is growing, but there are still areas that require further exploration. More research is needed to understand the specific mechanisms through which delivery efficiency influences customer satisfaction and to identify strategies for enhancing delivery efficiency in different contexts (Liu et al., 2013). This study provides significant insights and evidence-based recommendations for businesses seeking to optimize their logistics network design, gain more delivery efficiency and flexibility, and increase customer happiness.

2. Literature review

Delivery Efficiency

Delivery efficiency can be broadly seen as the effectiveness of a system in delivering its intended output. It refers to the ability of the system to deliver products or services to the end customer in the most cost-effective and timely manner. It encompasses aspects such as speed, reliability, cost-effectiveness and the ability to meet customer requirements (Prajogo et al., 2016). The concept of delivery efficiency has evolved over time, with an increasing emphasis on customer satisfaction. Delivery efficiency is a critical aspect of logistics network design, as it has a direct impact on customer satisfaction. An efficient delivery system ensures that products are delivered to customers in a timely and cost-effective manner, thereby increasing customer satisfaction. In addition, efficient delivery systems are also likely to be more flexible and responsive to changes in customer demand, further enhancing customer satisfaction (Prajogo et al., 2016). An efficient delivery system delivers products quickly, at low cost, reliably, with the flexibility to adapt to changes in demand, and in a manner that meets the specific requirements of the customer (Slack, 2005). Delivery efficiency is critical to achieving customer satisfaction, as it has a direct impact on the customer experience. Efficient delivery systems ensure that customers receive their products quickly, at a reasonable cost and in a manner that meets their specific requirements. This enhances customer satisfaction and can lead to increased customer loyalty and repeat business (Liu et al., 2013).

Delivery flexibility

Delivery flexibility is the ability to adjust delivery dates and to accommodate rush and special orders (Slack, 2005). It is the order winner over price and the ability to accommodate last-minute changes to order quantities, small-batch deliveries, fast deliveries, and higher on-time delivery rates Ketokivi (2006). Stevenson & Spring (2007) describe delivery flexibility as the capacity to adjust the delivery process in response to changes in the market environment. With the integration of technologies such as real-time tracking, data analytics and automated delivery systems, businesses are able to achieve higher levels of delivery flexibility. Delivery flexibility is crucial for organizations in achieving customer satisfaction. It allows firms to manage demand planning more effectively across extended enterprises and global supply chains (Lee and Park, 2008; McAfee and Brynjolfsson, 2012; Waller and Fawcett, 2013). Through delivery flexibility, firms can develop more collaborative relationships with customers and suppliers based on a deeper understanding of market demands. This enables the supply chain to respond more quickly and effectively to changing customer and supplier needs (Sanders, 2014). Sharing credible and accurate information, which emphasizes the quality of data, was associated positively with the ability to react to product change (Gosain et al., 2004).

Logistics Network design

Logistics network design is a strategic decision-making process that determines the structure, size, and location of facilities within a supply chain (Biswas & Samanta, 2016). Cheong et al., (2007) argue that the design of a logistics network is concerned with defining number and locations of warehouses and production plants, assigning to the warehouses customer demand points and assigning to manufacturing plants the warehouses. Logistics network design has evolved over time to incorporate sustainability and reverse logistics. Sustainable supply chain network design has emerged, integrating principles of life cycle assessment into supply chain network design models (Mehrerjedi & Shafiee et al., 2021). Network-design choices such as regional changes in production and use, market segmentation, emerging markets and client-service requirements, energy costs rise and maintenance of plants and equipment, function, regulatory and legalization, abundance of goods and shortened product life cycles have an effect on several factors. These factors have helped to increase demand volatility and led to the need for a good and well-designed Supply Chain Networks (Melo et al., 2009). This is achieved at hubs that may require consolidation. This makes it intelligently possible for an optimum supply network to reduce overall costs by supplying consumers with the right product in the right volume, in the right location and at the right time.

Delivery Efficiency and Customer Satisfaction

Emerging research suggests a distinct and positive correlation between efficient delivery and increased customer satisfaction. It is evidenced that enhanced delivery efficiency may drive customer satisfaction and consequently, boost consumers' willingness to pay (Singh & Basu, 2023; Nguyen et al., 2018; Zhao et al., 2008). Mentzer et al., (2001) identified customer service as a pivotal intermediary between integration and firm performance. By improving delivery efficiency, firms can enhance service quality, resulting in a rise in customer satisfaction. Furthermore, Davis et al., (2008) indicated that efficient and timely delivery is crucial to maintaining robust customer-supplier relationships and enabling reliable information exchange. As such, delivery efficiency significantly influences supply chain performance and, in turn, customer satisfaction. Based on the above argument, it is hypothesized that,

H1: Customer satisfaction is positively influenced by higher levels of delivery efficiency.

Delivery Flexibility and Logistics Network Design

The concept of flexibility is increasingly acknowledged as instrumental in logistics network design. Flexibility provides a process-oriented perspective and extends beyond mere developmental functionalities. Particularly relevant in volatile supply chain environments, flexibility allows for prompt and efficient adaptation of supply sources, logistics networks, and information delivery systems, facilitating swift reaction to change (Jafari, 2022). It allows firms to manage demand planning more effectively across extended enterprises and global supply chains (Lee and Park, 2008; McAfee and Brynjolfsson, 2012; Waller and Fawcett, 2013). This study proposes that delivery flexibility can increase order fulfillment, responsiveness, reliability, and convenience, all of which are important elements in affecting customer satisfaction and sustaining long-term customer relationships.

H2: There a significant relationship between Delivery flexibility and customer satisfaction.

Delivery efficiency and flexibility, Logistics Network Design and Customer Satisfaction

Modern supply networks consist of a variety of logistics and distribution organisations, and logistics networks have become increasingly sophisticated, with the ability to move goods quickly between firms to meet consumer expectations and expose the relationships between different supply chain flexibility measures (Singh & Basu, 2023). The logistics network determines the physical infrastructure and operational layout, enabling the efficient movement of goods from the point of origin to the final destination. The design of the logistics network shapes the capabilities and constraints that underpin delivery efficiency and flexibility, and ultimately affects customer satisfaction. This is because a well-designed logistics network with strategically located distribution centres and optimal transportation routes can improve delivery efficiency by reducing transit times, lowering transportation costs, and increasing order fulfillment accuracy (Chopra & Meindl, 2015). Similarly, an agile logistics network design that allows for rapid reconfiguration of resources and routes can improve delivery flexibility and enable timely responses to changing consumer demands (Fernie & Sparks, 2010). Consequently, logistics network design improves the relationship between delivery efficiency, delivery flexibility and customer satisfaction by designing the operational capabilities and constraints that enable efficient and adaptive delivery operations. Given the aforementioned empirical evidence, it is hypothesized that

H3: A well-designed Logistics network would significantly mediate the relationships between delivery efficiency and flexibility and customer satisfaction.

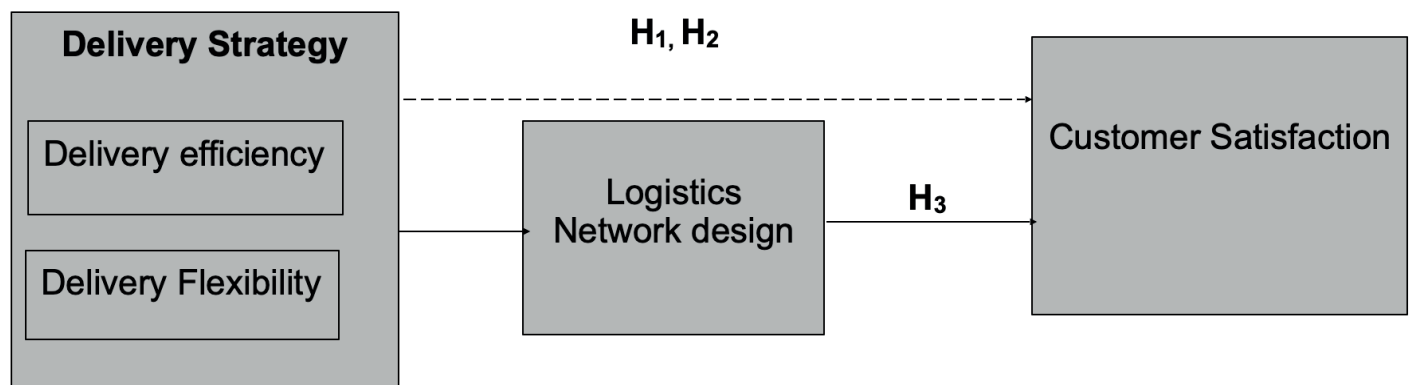


Figure 1 Research model

3. Methodology

The study uses a single cross-sectional survey data, collected from 100 supply chain actors using convenience-sampling techniques of major manufacturing companies in Ghana. Construct measurement items were generated through literature review and definitions. The measurement items for delivery flexibility were adopted from Moon et al., 2012; Swafford et al., (2006). Delivery efficiency measurement items were adopted from Bunger (2013) and Koste et al., (2004). In the case of logistics network design, the measurement items were adopted from Goyal et al., (2018) and finally the study the adopted measurement items of Pujawan, (2004) to measure customer satisfaction. Different actors responded to different constructs in the study to reduce common method bias. To ensure the validity and reliability of the measurement items of the constructs, both convergent validity and discriminant validity other validity were performed using smartPLS. The final list of the items that actually measured the study constructs, the factors loadings, the associated t-values, the Cronbach alpha values, the composite reliability, and the discriminant validity measured using the average variance extracted were presented. The result shows that the minimum cut-off criteria or standards of 0.70, 0.60, and 0.50 respectively were met (Bagozzi and Yi, 2012). All of Cronbach's alpha values were greater than 0.70 and hence exceed the standard of 0.70 (Nunnally, 1978).

4. Results and discussion

Measurement Model Analysis

The PLS-SEM analysis begins with measurement model analysis (Hair et al., 2017). Hair et al. (2020) expounds that the measurement model analysis assesses the variance between latent and observed variables. Typically, a measurement model analysis includes a test of convergent and discriminant validity. The study tested for convergent validity by measuring the psychometric properties of the constructs. The psychometric properties examined were Cronbach's alpha, Composite reliability, Item Loadings, rho A, and Average variance extracted (AVE). The results indicate that apart from customer satisfaction, which saw seven items, dropped because they fell below the acceptable thresholds, all the measurement items are within acceptable validity and reliability thresholds. This shows that the measured items used to assess these constructs are consistent and reliable, and that the constructs themselves are valid indicators of the concepts they are intended to measure. This increases confidence in the findings of the study. Discriminant validity can be proven by connecting one construct to another (Hair et al., 2020). In this study, discriminant validity was determined with cross-loadings, Fornell Lacker criterion and HTMT ratio of correlation tests. All the parameters met the acceptable thresholds.

Structural Model Results

An assessment of the structural model follows the measurement model test. PLS analysis explained the magnitude and significance of the hypothesized causal relationships as standardized path coefficients. The parameter estimate of the hypothesized structural path should be statistically significant with the hypothesized direction of the effect. Bootstrapping analysis is a non-parametric approach for estimating the precision of the PLS estimates. A path is statistically significant if its p-value is less than the 0.05 significance level. The results of the PLS analysis with bootstrapping reveals that all hypothesized direct effects of the research model were statistically significant as in figure 2.

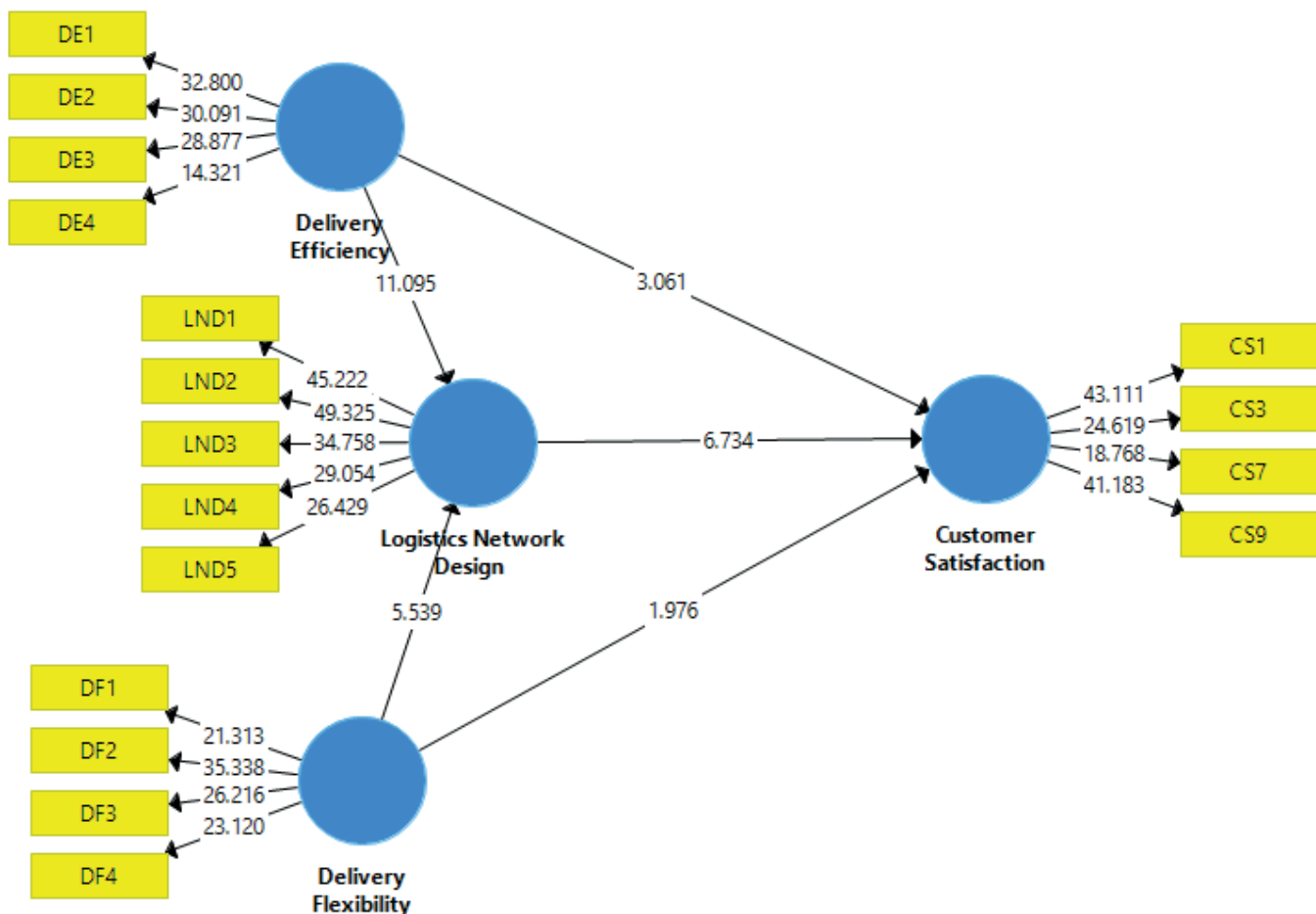


Figure 2 structural Model

This study aims to examine the relationships between delivery efficiency, delivery flexibility and customer satisfaction. It also seeks to investigate the mediating role of logistics network design. By analysing the mediating effect of logistics network design, this research seeks to shed light on the mechanisms through which delivery efficiency and flexibility affect customer satisfaction. In addition, by analysing the impact of these factors, the study aimed to improve our understanding of how organisations can optimise their delivery processes and logistics network design to improve customer satisfaction. It was hypothesised that delivery efficiency would have a positive effect on customer satisfaction. The results of the hypothesis testing revealed a significant positive influence of delivery efficiency on customer satisfaction. This finding supports the argument that efficient logistics activities contribute to improved customer satisfaction (Amine and Gabriela, 2017). The study further investigated the impact of delivery flexibility on customer satisfaction. Based on the existing literature, it was hypothesised that delivery flexibility has a positive impact on customer satisfaction. The results confirmed this hypothesis, indicating a significant positive impact of delivery flexibility on customer satisfaction. This finding is consistent with the study by Duclos et al. (2003), which emphasised the importance of flexibility improvements in increasing customer satisfaction by meeting diverse customer needs, personalising deliveries, accommodating unpredictable demands and adapting to market changes. The study also examines the indirect influence of logistics network design, hypothesising that logistics network design would mediate the relationship between delivery efficiency, delivery flexibility and customer satisfaction. The results show that the mediating effect of logistics network design is statistically significant, implying that the influence of delivery efficiency and delivery flexibility on customer satisfaction is substantially mediated by logistics network design. This result implies that improved logistics network design allows for faster and more dependable deliveries, as well as greater flexibility in routing and allocation, enabling more responsive and customised delivery services that improve customer satisfaction.

5. Conclusion

The study supports and extends previous theoretical grounds by providing empirical evidence of the significant effects of delivery efficiency and flexibility on customer satisfaction. It contributes to the theoretical foundation by demonstrating the importance of these factors in improving customer satisfaction outcomes. The study also contributes to the logistics and supply chain management literature by establishing the mediating role of logistics network design, highlighting the importance of logistics network design in optimising delivery operations and achieving customer satisfaction. The findings emphasise the need to invest in delivery efficiency and flexibility in order to improve customer satisfaction. Companies should prioritise optimising their delivery processes, eliminating delays and ensuring timely and accurate deliveries. This may involve adopting new technologies, increasing collaboration with suppliers and customers, and establishing effective inventory management procedures. Managers need to recognise the importance of logistics network design in influencing customer satisfaction, as a well-designed logistics network can increase operational efficiency, save costs and ultimately improve customer satisfaction by enabling faster and more reliable deliveries. In addition, to meet changing customer expectations and preferences, companies should emphasise flexibility in their delivery processes. This could include offering multiple delivery alternatives, allowing order revisions and providing real-time tracking. While the study provides important insights, there are a number of limitations that should be noted as a basis for future research. The study used several manufacturing firms from different industries. Further studies could consider industry-specific firms to provide a deeper understanding of the relationships between the constructs in a particular context. This study also suggests that future studies can explore the contingent role of supply chain ownership and fragmentation in the relationships.

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INVESTIGATING THE APPLICABILITY OF NEXT GENERATION TECHNOLOGY TO MANAGE THE DAIRY SUPPLY CHAIN DISRUPTIONS IN EGYPT

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I. INTRODUCTION

The dairy supply chain (SC) has experienced significant losses due to the perishable nature of dairy products and the lack of traceability and control over raw materials, particularly raw milk. When farmers face a shortage of raw milk supply or have no storage capacity for surplus milk, disposal becomes the only option, resulting in substantial revenue loss. The COVID-19 pandemic further disrupted the dairy industry, as the closure of restaurants, hotels, and schools led to decreased demand for dairy products (Tate, 2017). To address these issues and mitigate the disruptive effects on the dairy sector, research efforts have been directed towards identifying techniques and strategies that can alleviate the impact. This research aims to explore potential mitigation techniques specifically tailored to the dairy industry. It focuses on Egypt as one of the promising markets, actively seeking to develop its dairy sector to meet local demand and enhance its performance by increasing exports to the global market. By identifying and implementing effective solutions, Egypt aims to uphold its contribution to the dairy industry and foster sustainable growth in this crucial sector. By studying the challenges faced by dairy SCs, including the issues of perishability, traceability, and control over raw materials, as well as the unprecedented disruptions caused by the COVID-19 pandemic, this research seeks to provide valuable insights and recommendations for enhancing the resilience and efficiency of the dairy industry. Through these efforts, stakeholders in the dairy sector can work towards minimizing losses, ensuring product safety, and optimizing the overall performance of the SCs (Euromonitor, 2020).

II. LITERATURE REVIEW

A. Dairy Supply Chain

While many people drink milk products regularly, not many are aware of the extensive SC that carries this dairy staple from the farm to the supermarket. The dairy SC becomes very sensitive to connectivity and requires vital care (Federation, 2021). Dairy farmers follow strict logistics requirements to ensure the freshness and safety of dairy products. Dairy SCs are complex, as the selection of dairy products on the market becomes exceptionally extendible.

B. Dairy Supply Chain Disruptions

Dairy plays a vital role in agricultural-based economies. The dairy SC, with its multiple stakeholders, is particularly susceptible to disruptions due to inherent vulnerabilities. These vulnerabilities are amplified by the perishability of raw milk (Bigliardi et al., 2022). The COVID-19 crisis has led to numerous disruptions in SCs, increasing uncertainties in various industries, including the dairy SC (Karwasra, 2021). The perishability of dairy products further complicates the situation. Espitia et al. (2020) agreed that the agricultural SCs were affected and revealed unprecedented risks following COVID-19 crisis. Thus, quantifying vulnerability and developing mitigation techniques enhances the resilience of the dairy SC. Interpretive structural modeling (ISM) and graph theory approach (GTA) identify critical operators of vulnerability to develop a model for quantifying and calculating the SC vulnerability index in the dairy SC. Karwasra (2021) emphasized the need to investigate risks and build resilient agricultural SC. The research found that external risks, including market dynamics, financial factors, logistics, infrastructure, management strategies, policies, and environmental concerns, have a significant impact on agricultural SCs, contingent upon market conditions. The research recommends adopting industry 4.0 technologies, SC synchronization, shared responsibility, and risk mitigation techniques as potential solutions for ensuring a sustainable future.

Li et al. (2019) recommended taking prompt action to address COVID-19's impact on food security, emphasizing that bolstering local food supplies can reduce the likelihood of global supply shortages. Adjusting a proactive approach to a future disruption caused to food SCs, managers should consider a chain that can be adjustable, and resilient. In addition,

introducing the use of worldwide technical data platforms to cope with supply and demand shocks is important for transparency (Li et al., 2019). Kritika (2021) stressed the need for effective and responsive food SCs following the impact of COVID-19. The research highlighted the growing importance of sustainability, traceability, and digitization in the food SC. Further, ensuring the safety and security of domestic food SCs was emphasized. Rohit (2020) investigated traceability, transparency, and information flow in the dairy SC, emphasizing the critical role of an efficient traceability system in managing food quality and safety risks. This research underlines the significance of transparency among government agencies, consumers, food industries, safety standards, and information systems to avoid disruptions within the SC.

C. Dairy Supply Chain Disruption solutions

In this technology-driven era, businesses strive to implement tracking technologies in their dairy SCs for better control and performance optimization. Espitia et al. (2020) investigated the benefits and challenges of using tracking technologies such as barcodes, RFID, and intelligent packaging systems with temperature indicators. Accordingly, Blockchain offers potential solutions and insights into the limited implementation of technologies in fresh produce SCs (Hofman, 2020). These studies clarify the exceptional opportunities and challenges associated with adopting Blockchain. Implementing Blockchain can facilitate a transformative shift in agri-food SCs, promoting transparency and trust among partners which is a central objective of the entire chain. Effective communication and technology-driven infrastructure, using Blockchain, is vital for ensuring food safety and traceability in SCs.

D. Digitalization

The twentieth century witnessed remarkable technological advancements. Industry 4.0 has garnered significant attention globally. Digitalization as a process enables optimal solutions for disruptions throughout the dairy SC, from farm to consumer consumption. Thus, digitized technologies, classified under Industry 4.0, have been implemented in various countries and industrial sectors (Singh et al., 2020). It has revolutionized the dairy SC management (Madeleine, 2019). Therefore, technologies like Blockchain, Smart Machines, and the Internet of Things (IoT) play crucial roles in enhancing resource planning, logistics, manufacturing productivity, and operational management techniques. Additionally, digitized practices improve competitive capabilities by enabling effective tracing of materials and final products, which requires synchronization among chain partners (Bigliardi et al., 2022). Moreover, digitizing food SCs addresses sustainability and resilience concerns (Jachimczyk et al., 2021). Therefore, Industry 4.0 technologies in summary have benefits including; traceability, sustainability, crisis response, and improved agricultural SC management. Implementation barriers include infrastructure, costs, knowledge, regulations, and technology alignment. Overcoming these barriers requires supportive policies, infrastructure development, and training. Therefore, effective implementation and management of technologies like Blockchain can offer significant benefits to the food SC. Despite being in the early stages of adoption and exploration, Industry 4.0 has raised concerns about the role of humans within this technological environment. Sanders et al. (2016) have specifically addressed the crucial role of human resources in logistics under Industry 4.0. The concept of the next-generation industry has evolved to minimize human involvement, with robots potentially replacing humans throughout the entire production and delivery process. This development poses a potential threat of exclusion for human workers.

E. Industry 5.0 Approaches to Dairy Supply Chains

Industry 5.0 integrates robots with human capabilities, known as the 'cobot' concept, leading to rapid development (Cimini et al., 2020). This concept combines elements of Industry 4.0, such as Artificial Intelligence (AI), big data analytics, and IoT, to enable intelligent work environments. While Industry 5.0 is still in its early stages, it aims to digitize processes while emphasizing the importance of human labor. Research in this area is limited due to its nascent nature. Industry 4.0 serves as the foundation for intelligent manufacturing sites, with organizations leveraging its technologies for competitive advantages. Accordingly, Industry 5.0 would be based on innovative social communicative factories. The media of communication between buildings and humans will be achieved through firms' social networks (Kent, et al., 2020). Industry 5.0 presents a knowledge gap in understanding its impact on the dairy SC and other chains. While there is some understanding of Industry 4.0, Industry 5.0 remains unclear. Limited knowledge exists regarding its effects on SC members and processes. As this current research aims at exploring potential mitigation techniques for minimising disruption in the dairy supply chain. The key research question remains:

RQ1: how next generation technology could be deployed to fully automate dairy SCs from farm (cows) to consumer?

F. BlockChain implementation in the Dairy Supply Chain

Centralized SC management systems may pose risks of disruptions and fraud. BlockChain technology offers improved visibility and transparency in SC flows, creating a dependable, transparent, and secure system (Salamah, 2021 and Amentae and Gebresenbe, 2021). Malpractices during logistics processes, especially in handling and transportation, can pose risks. Milk-related scandals are increasing globally, particularly in developing countries like China, India, and Pakistan. This highlights the importance of traceability in milk and milk products (Azzi, Chamoun, and Sokhn, 2019). Thus, food traceability is essential for safety and quality, with logistics operations playing a vital role (Li et al., 2019). In the dairy industry, BlockChain can revolutionize traceability by ensuring transparency and overcoming obstacles. This can be done by the chain members registering in the BlockChain network, creating unique identities, and updating information, using RFID tags, as milk and milk products move through the SC (Behnke and Janssen, 2020).

III. methodology

Limited research has been undertaken to explore this topic in Egypt. That is why the researcher relied on the interpretivism paradigm as research philosophy, which best explores the phenomena, where theory is being defined rather than tested. Moreover, it provides a detailed understanding of what purpose and why things occur, as it investigates solutions to ease the impact of disruptions, such as COVID-19, on the Egyptian dairy sector.

Narrative literature review approach was followed to cover a broader scope of sources supported by technical and organizational reports, conferences, and governmental records. The search process included the following keywords (operational capabilities, dairy, COVID, CORONA, and supply chain). Regarding selection criteria, peer-reviewed research papers were published in English between 2016 and 2021. Then extended to include research beyond this period to ensure that the research is covered from different perspectives. This research is built based on the search process of the following journals, like: International Journal of Information Management, Journal of Business Logistics, Journal of Dairy Science, and Journal of Halal Product and Research. The exclusion process started with scanning the research title, then the research abstract, and excluded research unrelated to the dairy and food sector.

Two focus groups (FGs) were conducted to validate the literature review findings by addressing SC disruptions and identify solutions to overcome such disruptions. The FGs were held virtually on ZOOM software for approximately two hours. Each FG represented five categories of respondents: 1) large dairy producers, 2) the National Food Safety Authority (NFSA), 3) the Ministry of Agriculture, 4) TetraPak, and 5) powdered milk suppliers. The FGs' output was qualitative data. Following the same philosophy, qualitative data was the most fitting data type to be gathered, because researchers are exploring a new research setting that has not been addressed in this region yet. Therefore, it is necessary to focus on narrative data rather than numeric ones. The research papers included in the literature section and the focus group transcripts were logged in NVIVO12 Pro software to ease tracking the word frequency and supporting the themes extraction process. The researchers screened all files and reduced the data to form critical themes and sub-themes. The time horizon of the research was a cross-sectional research in which FGs data were gathered and analyzed just once from the FGs to compare the relevance of the literature findings to the Egyptian dairy sector context.

IV. ANALYSIS & RESULTS

The analysis started with reviewing previous research and the FGs narratives, then summarizing it to extract the themes appearing from the text. Thematic analysis was conducted by using NVIVO12 to find a match of themes validating the main themes covered in previous literature to validate its relevance to the Egyptian dairy sector. The following sections represent the findings of the literature and the FGs which conform to the research aim and answers the research question. It is centered around applying the next generation technology to achieve full visibility in the dairy sector as a focal mitigation technique to control the disruptions and find solutions proactively.

Four themes were generated from FG transcriptions. Those are Technology Utilized, SC Integration, Operational Efficiency, and Challenges to Digitization Application. The following figure shows a word cloud of the most Hundred frequent words appearing in the FG transcriptions. It is created based on the selection of stemmed words with a minimum length of four letters. The researcher found the similarity between the most frequent words appearing in the word cloud and the literature findings which serves to achieve the research aim like; milk products, dairy producers, systems, development, improve, farms and suppliers. Those keywords emphasized the appropriateness of the data gathered to explore the next generation technology to ease disruptions through traceability.



A. Technology Utilized

B. Supply Chain Integration

As the FG discussion focused on what lacks the dairy industry. Integration and traceability were used by the participants as a key factor for the dairy SC. The SC integration referred to it as traceability by the participants. They mentioned that the word integration extends further than collaboration and partnership to achieve traceability from “supplier zero” as named by the NFSA head, until it reaches the retailers. Supplier zero is the original source of supplies. Evidence supporting that is: “We are working towards this goal in integration with hub idea”, and “the producer takes less amounts of raw milk from the suppliers and the producers...delay the raw milk receival from the suppliers for one or two days. That reflects badly on the suppliers (the farms) and the livestock themselves...I agree with my colleague in terms of the collaborative planning between the producer and the supplier to sustain the supply process based on a trusted relationship between both of them”. Accordingly, the integration through traceability among all SC members will enable them to overcome the challenges which they might face by providing better collaboration and demand planning and less waste of resources.

C. Operational Efficiency

This theme explained the operational efficiency to ensure sustainable performance through six measures, including: human factor, delivery, cost, productivity, quality, health and safety, and environment. “The production line efficiency. The efficiency means, I’m calculating how many packs produced in a specific time with which quality”. The head of livestock development in the ministry of agriculture mentioned: “our hope to increase the efficiency of the small and medium farms...with the milk collection center, I deal with around 50 or 30 sources. So, I need to increase the efficiency of those collectors to enhance their raw milk quality to reach the quality of raw milk coming from large farms...We will provide them with the tools and equipment to test the adulteration, the antibiotic residues, mycotoxins, or pesticides”. This means that the operational efficiency of the suppliers or the factories separately will impact the overall SC efficiency. That requires comprehensive measures covering all the dimensions of the SC with an extensive focus on the human factor even though the trend is towards digitization.

D. Challenges to Digitization Application

This theme discusses the challenges of adopting digitization by the dairy SC members. Large investment of capital is required to set up the infrastructure to connect them. Also, resistance to change was noted from the suppliers specifically. Either due to a lack of awareness of its applicability or their lack of trust to have on-time sharing of their data. That also appeared in the distribution side of the SC but not as challenging as the supply side. A milk powder supplier general manager supported this by mentioning: “the challenge appears when the market needs this raw fresh milk, and it is not available”. Also, the NFSA head mentioned: “The whole issue is in the livestock area. I have spotted three words you have mentioned here; traceability, suppliers, let’s talk about them and specifically the supplier zero...who owns the cow. So, that is the primary problem, this kind of milk brought from this supplier. So, I will link the traceability with the supplier and the milk specifications”. The participants focused on the collaboration to overcome challenges in the dairy SC like the lack of raw milk, the delay of delivering it to the factory, the resistance to change of small farmers to collaboration and learning new techniques and technology to preserve the milk quality. All this was evident by the participants to be solved by providing a traceability network connecting all relevant members.

V. FINDINGS

Figure 2 summarizes the themes recorded in the literature to be grouped under two main themes. First, the dairy SC disruptions cover seven sub-themes. Those are supply, demand, financial, logistics and infrastructure, policy and regulations, management and operational, and biological and environmental. All these disruptions are critical to the dairy product’s safety due to its perishability nature. The second theme is dairy SC disruptions’ solutions. It covered digitization to include industry 4.0, 5.0 and BlockChain. This led the researchers to validate these themes from the key stakeholders in the dairy sector in FG form to examine the feasibility of applying new technology in the Egyptian dairy sector.

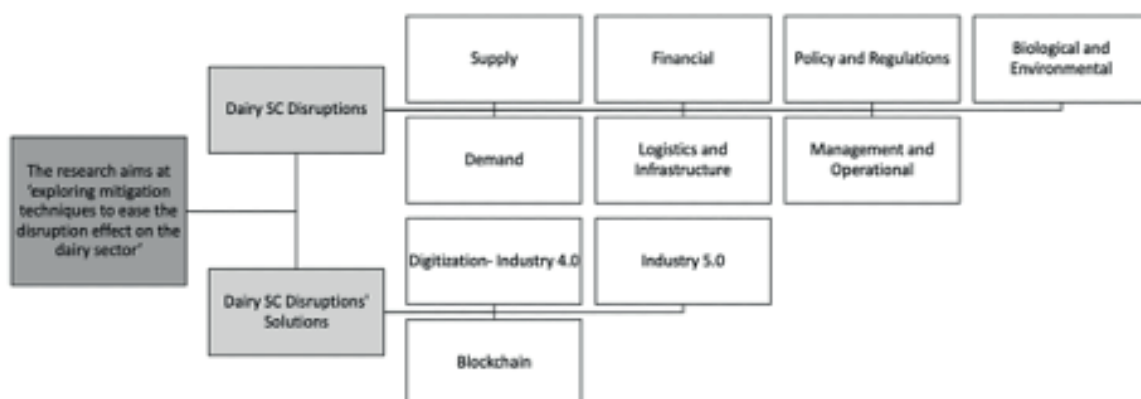


Figure 2: Literature Findings

Figure 3 summarizes the FGs findings to achieve the research aim. The participants focused on traceability and integration among the SC members and utilizing the available technologies to overcome the challenges towards digitization and its role towards operational efficiency. The FG findings showed a positive indication towards adopting advanced technology. This

will ease the challenges towards the application of digitization to track the available sources of raw milk. That reduces the delay of delivering the milk and other supplies to the factories. But the only challenge remains is the resistance to change to adopt new technology. However, dairy producers and NFSA provide periodical training programs to small farmers and milk collection centers to adapt to change. All this will contribute to managing the operational efficiency.

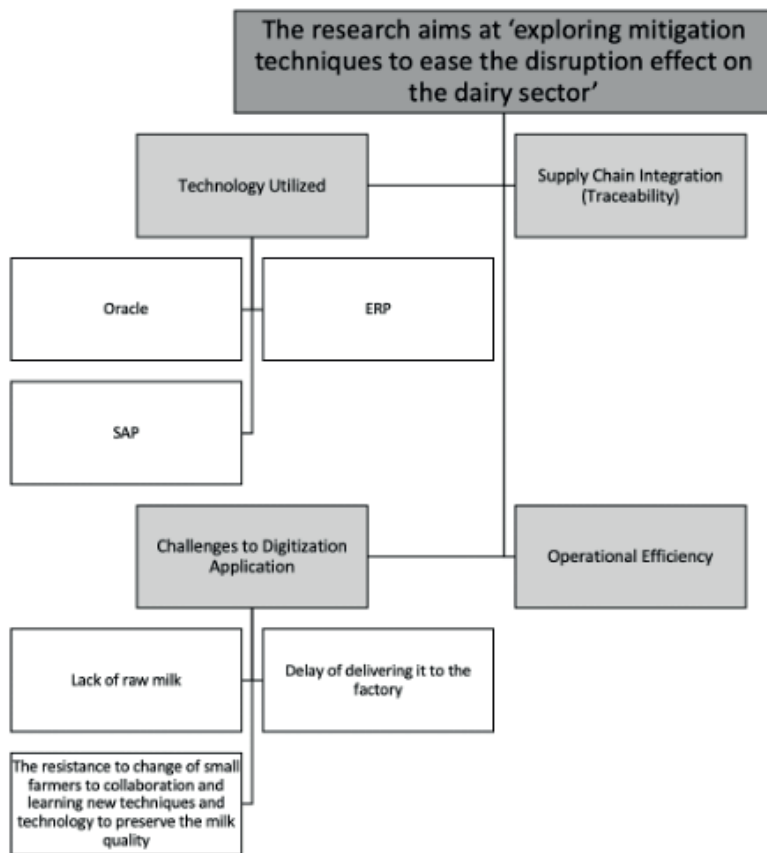


Figure 3: Focus Groups' Findings

As noted through the research process, the emerging research published in the area of digitizing the perishable dairy SC is limited. It appears that the Egyptian dairy sector is thriving to reach an optimum level of sufficiency. Simultaneously, according to the current performance of dairy chains, they lack the complete integration and visibility among the SC members and supplier zero specifically. Although the Blockchain, Industry 4.0 and 5.0 were not mentioned explicitly in the FGs, technology adoption was key. This appeared by explaining how dairy producers adopt different software like the SAP and ERP at the factory level and different Oracle modules at the warehouse level to monitor their stock levels. This sets a great potential to prove that the Egyptian dairy SCs are prepared to adopt next generation technology and connect all SC members to reflect the trust among them by achieving full visibility of materials and products' movement.

The key words; Blockchain, Industry 4.0 and 5.0 were hardly recorded in the FGs. This magnifies the research gap that needs to be furtherly addressed in the subsequent action research. The following section summarizes the research process and highlights potential future research.

VI. CONCLUSIONS

This research reviewed previous research looking for solutions to improve the transparency among the dairy SC members in terms of on-time traceability to enhance the products' safety, ease the disruptions and maintain the business sustainability. That was summarized in the current technology utilized to include Oracle, ERP, and SAP. This enables the Egyptian dairy SC to migrate towards next generation technologies. The FGs proved the eligibility of the key stakeholders to adopt the next generation technologies to strengthen the collaboration in terms of full on-time visibility and trust among the members.

Although most of the global SCs are facing different disruptions, COVID-19- for instance- shifted the attention towards advanced technologies. Thus, global SCs which relied on technology in their practices eased the disruptions of data sharing. But they lacked full traceability among all SC members. This was proved beneficial to the Dairy SC through the FGs which were conducted. The dairy producers, the suppliers, the governmental authorities, and the food safety authorities expressed the urgency to have a fully integrated system connecting all the entities to share on time data with full visibility and trust which reduces the disruptions represented in delay or lack of resources. This opens chances for future research to furtherly test the applicability of the next generation technology by utilizing empirical research.

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A FRAMEWORK TO DESCRIBE ELECTRIFICATION OF LOGISTICS SYSTEMS

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Introduction

Movement of goods using road freight transports has a vital part in our society, but accounts for large amount of CO₂ emissions (IEA, 2019). The demand of freight deliveries is expected to continue to rise, while environmental goals to reduce CO₂ emissions are enforced both nationally and globally. This forces the sector to transition to more sustainable ways of transporting goods. Electrification of freight transports has been highlighted as one of the more prominent ways of reducing the sectors climate impact, where on-board batteries with stationary charging is the most developed technique (Noll et al., 2022). Transportation is a central part of logistics systems, where logistics systems can be described as planning, implementing, and controlling flow of goods in an efficient manner (Stock & Lambert, 2001), and transition to electric trucks will have large impact on such systems. Firstly, charging must be included in planning of deliveries, and several charging strategies can be applied (Kin et al., 2021; Teoh, 2022). Secondly, electric trucks have a more limited range compared to diesel counterparts which can limit their use in existing systems (Alp et al., 2022). Thirdly, the weight of the batteries might decrease the loading capacity (Li et al., 2022). Fourth, the investment cost for the trucks is much higher compared to diesel trucks, which can make logistics firms more reluctant to transition (Noll et al., 2022). However, the cost for the electricity is lower than the cost for diesel so, despite the higher investment, the future total cost of operation (TCO) may in many cases be lower than for diesel trucks (Karlsson & Grauers, 2023). Still, the above-mentioned limitations affect different types of transport segments in different ways. One rough way to differentiate transports segments is based on distance, e.g. urban deliveries, regional deliveries, and long-haul deliveries (Noll et al., 2022). The range limitation is not as prevalent for urban deliveries due to the shorter delivery distances, compared to long-haul deliveries.

Even if the technology advancement is moving at a fast pace, there exist uncertainties on how electrified logistics systems should be designed, which hinder the transition (Gillström et al., 2022). So, despite relatively high level of technology maturity, the system maturity is still low (see e.g. Sauser et al., 2006). It is thus important to raise understanding of how the system readiness can be increased and how to account for aspects that affect logistics systems. This calls for a framework that can be used to increase our understanding of logistics systems and what effects electrification has. The purpose of this paper is to develop a framework to describe electrification of logistics systems by combining transport segments and what type of electrification strategy is suitable for which segment. The framework can be used to highlight how different types of transport segments are affected by electrification and thus build an understanding of what is needed to transition to electrified logistics systems.

Frame of reference

Logistics systems and transport segments

Important aspects for managing logistics systems are to secure that end-customers demand is fulfilled when it is needed, with the right quality, and at a competitive cost. Other important aspects are controlling variability and dealing with uncertainties (Harrison & van Hoek, 2008). Wandel et al. (1992) presents a three-layer model that can be used to describe logistics systems. The model consists of the three layers: material flow, transport flow, and infrastructure, and with markets between each layer (i.e. where supply and demand are met). The material flow cover goods need to be transported, while transport flow cover the movement of the goods. Between the first two layers is the transport market. Here the demand from transport buyers must, in terms of requirements of the deliveries, be matched to the supply from logistics companies, and this market is often highlighted as a central part of logistics systems (Harrison & van Hoek, 2008). The last layer is infrastructure, which concerns physical nodes and links (Wandel et al., 1992). The market between transport flow and infrastructure is called traffic market and can be described as the actual flow, which can be restricted by traffic restrictions, congestion, and queues.

It has already been highlighted that transport can be segmented based on distance, i.e. short (urban), regional (medium), long (long-haul). However, there are other factors that can be used to segment transport. Rodrigue (2020) presents the following factors, Whether the routes are point-to-point; number of nodes during the route; whether the route is fixed or dynamic (i.e. possible to alter depending on new circumstances); whether routes are continuous or divided between nodes; and load and capacity of the trucks during the route.

Impact of electrification and charging strategies

Reduced flexibility in planning transport assignments, uncertainties regarding the TCO, and accounting for longer stand-still time due to charging are challenges often highlighted when transition to electric trucks (Li et al., 2022). Kin et al. (2021) highlight four different charging strategies that can be used: Home charging, terminal charging, charging beside roads, and charging at premises (not own terminal). Home and terminal charging are often private and low charging power are used since overnight charging is often used (Kin et al., 2021; Teoh, 2022). Chargers beside roads is often public with high power to reduce the charging times (Teoh, 2022). Charging at other premises is often semi-public and can, for example, be at drop/pick-up locations and are often with high power (Kin et al., 2021). The charging strategy used is also strongly connected to the type of transports. Deliveries originating and finishing at the same terminal (e.g. urban deliveries) often apply overnight charging, where charging at the terminal often is sufficient (Quak et al., 2016). For longer range deliveries, where the distance of the assignment or the return journey exceeds the range of the truck, charging at other places than 'home terminal' is needed (Alp et al., 2022; Kin et al., 2021).

Methodology

Following the logic of the purpose, traditional logistics and transport literature is combined with electrification literature and empirical results to construct the framework. Miles et al. (2014) presents a descriptive model called thematic conceptual matrix which can be used to align themes to predetermined factors and thus to describe phenomena and identifying patterns. A descriptive model strives to make complicated things understandable (Bernard, 1998) fit the scope of the purpose since electrification of logistics systems is often highlighted as complex with many parts affecting the system (Li et al., 2022). The descriptive model, in this paper called framework, include transport segments on one axis and charging strategies on the other axis.

The main empirical foundation for the presented framework is two ongoing electrification projects where actors, such as truck manufacturers, logistics companies, energy companies, and charging equipment manufacturers are included. One of the projects targets urban and regional context, while the other targets long-haul transport. There are currently electric trucks operational in the urban/regional project, while the trucks are expected to start operating for the long-haul project late 2023. Inclusion of electric trucks in real transport flows and inclusion a large variety actors pursuing electrification is still rare, hence the projects can be classified as high impact cases (Patton, 2014) which provide valuable insights that would otherwise be difficult to attain. The empirical scope consists of seminars and workshops held within both research projects, where a multitude of actors were present. As a complement to the insights from the research projects, nine interviews with persons having insights in the transport planning operation at logistics companies have been performed which focused on transport segments and factors that affect how the transports are planned. The analysis can be separated in two parts, which together constitutes the framework. The first part was to identify factors to describe transport segments and how they connect to electrification. The process can be likened to ladder of analytical abstraction (see Miles et al., 2014) and include coding the data based on literature and searching for relationships. The second part, identification charging strategies, can predominately be described as inductively based on the insights gained from the projects. Analyses of the strategies were based on a cost/benefits approach. Constructing the framework was performed inductively by the authors, with guidance of the results gained in the previous steps.

Results and Discussion

Identification of factors to describe transport segments

Several factors have been highlighted (e.g. Rodrigue, 2020) how transport can be segmented and results from the interviews confirm that these factors are relevant, and add other factors of relevance, such as planning horizon, variation of routes, and frequency of routes. By combining the literature (e.g. Rodrigue, 2020; Wandel et al., 1992) and results from the interviews, the following factors have been identified:

- Distance: Delivery distance, from first collection point to last delivery point.
- Number of stops: The number of stops for collection or delivery during one route.
- Planning horizon: The time in advance the transport assignment is planned.
- Variation in routes: How much the routes varies between different days.
- Frequency of routes: How reoccurring are different routes between days?
- Time for loading and unloading: The time each loading and unloading take.
- Returning to own terminal: After a shift, is the truck returning to own terminal or not?

How the factors affect electrification

The identified factors to described transport segments can also be connected to electrification, and how they can be enabling or preventing. Table 1 present the factors and their extreme cases, where each extreme case is classified as either enabler or preventer and based on empirical data and references presented in frame of reference (e.g. Alp et al., 2022; Li et al., 2022; Noll et al., 2022; Teoh, 2022). Worth noting is that it is the combination of all factors which ultimately affects to potential to electrify transport segments, but the individual factors provide guidance of aspects to consider when planning to electrify.

Factor	Enablers	Preventers
Distance	<i>Short distance:</i> Delivery distances are shorter than the capacity of the battery, hence no extra charge is needed.	<i>Long distance:</i> Charging must be included during the transport mission which complicate planning of transport
Number of stops	<i>Few stops:</i> By itself do not have direct effect but transport system become less complex.	<i>Many stops:</i> Can result in more detours and higher risk for congestion and more time-windows to match.
Planning horizon	<i>Long horizon:</i> The assignments are known in advance, which make planning and resource allocation less complicated.	<i>Short horizon:</i> More ad-hoc assignments which require flexibility, e.g. availability of truck with enough battery capacity and plan of charging.
Variation in routes	<i>Low variation:</i> Easy to predict where to charge. Also potential for high utilization of chargers due to same nodes are visited frequently.	<i>High variation:</i> More difficult to achieve high charger utilization, new chargers may be needed for different routes.
Frequency of routes	<i>High frequency of routes:</i> Like above, reoccurring routes have the potential of achieving high utilization of chargers.	<i>Low frequency routes:</i> Like above, but locations for chargers can be determined but with low utilization.
Time for loading unloading	<i>Long time:</i> Long loading or unloading time enable charging. Requires high power to be viable.	<i>Short time:</i> Not viable to charge during short loading or unloading.
Return to own term.	<i>Yes:</i> Enables charging at the terminal without extra planning.	<i>No:</i> Charging must be included in the planning and utilize public charging.

Table 1: Factors and how they affect electrification in terms of enablers and preventer

Charging strategies preferred during the transition to electric trucks

One very important part of logistics systems is having adequately infrastructure (Wandel et al., 1992), and in the case of electrification, charging infrastructure become vital. Furthermore, as can be seen in Table 1 above, many of the factors have direct ties to the type of charging set-ups used. To make good decisions about which transport segments to start electrifying, it is important to know that not all segments are suitable for the same charging strategy (Kin et al., 2021). Without understanding the differences there is a risk that conclusions from research and demonstration projects are wrongly applied to segments for which they are not valid, leading to either over- or underestimating the challenges of electrifying trucks. To mitigate business risks associated with chargers the logistics companies should consider the different risk levels associated with different type of chargers, when deciding charging strategy.

- Low risk: **Owned Chargers** or rented on a long contract means that the logistics companies have full control over their use, and the cost to charge (Kin et al., 2021).
- Medium risk: **Contracted public chargers** are used for chargers which are vital for operating the electric trucks but need to be shared with other vehicles to reach a sufficiently low cost per kWh. Their availability and price can be guaranteed for some years through contracts with the charger owner, or they can be built by the logistics companies and made public for others to use.
- High risk: **Public chargers** without contracts are a risk if the density of chargers is low, due to the risk for additional time required to drive to the charger and potentially need to queue before they are available (Teoh, 2022). Even if the density is high, these chargers risk leading to high charging cost, if the charging price increases. The risk when relying on public chargers will reduce much when there is a high density of public chargers and there is a stable balance between supply and demand.

Charging strategy	Development phases of public charger network			
	1. No public charger	2. Few public chg. High price.	3. Many public chg. High price.	4. Many public chg. Low price
A – All charging at owned chargers.				
B – Most charging at owned chargers, supplemental publ. chargers.	No public charger	Time to find public chargers increase salary cost	Low charging cost as public charging is rarely used	
C – Much charging at contracted public chg., rest at owned chargers.	No public chargers	Medium charging cost due to much public charging	As in step 2 but contracting chargers not necessary	
D – Much charging at public chargers, rest at owned chargers.	No public charger	Time to find public chargers increase salary cost much	Medium charging cost due to much public charging	
E – Mainly use public chargers.	No public charger	Time to find public chargers increase salary cost much	High charging cost due to mainly public charging	

Table 2: Suitability of five different charging strategies (A-E) during four development phases (1-4) of the public charger network. Green=good, Light green=good but medium-high charging cost, Yellow=possible but not preferred, Red=unsuitable strategy.

The suitability of different charging strategies during the development of the public charger network is shown in Table 2. It can be used to identify which charging strategies can be suitable during different steps of the development of public charging.

Before there is public charging infrastructure, step 1, the only possible charging is **strategy A**; to use only owned or rented chargers, in line with Kin et al. (2021). When there are few public chargers, step 2, charging strategies only using public chargers for some rare supplemental charging is possible, but the additional time for finding free chargers can increase the salary cost. The high price for public charging will not be a problem for **strategy B** as it applies only to very little of the total energy used. In step 2 it will only be possible to use public charger for much of the charging with **Strategy C**, in which access is guaranteed but with risk of higher cost (also identified by Teoh, 2022) by a contract with the charger owner or by building the required public chargers oneself. In step 3 with many public chargers, charging much at public chargers without any contract is good (**strategy D**), only with the caveat that the average charging cost will be medium-high since much of the energy will be charged at expensive public chargers, and the rest at low cost owned chargers. In step 3 there is no need to contract public chargers, but that strategy of course still works well. For strategy E using mainly public charging, it is first in step 4 that the charging cost will be low enough. This concept can also be used in step 3 but then the charging cost will be high and then other types of fossil free trucks may be a cheaper alternative than battery electric trucks.

Framework for combining transport segments and charging strategies

To understand which transport segments are suitable to start electrifying we also need to determine which transport segments can use which charging strategy. The transport segments are based on the previously mentioned factors. Seven segments are identified as relevant to analyse further and presented below in table 3. The selection of segments is based on a combination of factors that largely influence the potential to electrify the segments (the factors connection to electrification are presented in table 1). For example, the difference between the segments 'shuttle operation' and 'operates within a region' (both presented in table 3) is if the routes are varying or not. How routes vary have been highlighted by Teoh (2022) as a factor that can have a large effect on the potential to electrify segments. Table 3 connects the different transport segments with the charging strategies.

As it is low risk to use one's own chargers, that is preferred whenever it is possible without any significant negative effects, charging strategy A and B will likely be used for city distribution, in line with e.g. Kin et al. (2021) and Quak et al. (2016). As the truck drives longer and longer it is cost effective to increase the battery size in proportion with the increased driving range, however, then the battery becomes heavier. Initially that is not a problem, but at some range limit the battery weight will start reducing how much load the truck carries significantly (Li et al., 2022). Reduced load will reduce the earnings and thus make the truck less profitable. Exactly at which range the battery weight starts to reduce the load significantly depends on what type of goods is transported and the topography. For many trucks it is estimated to happen at around 250 km useful range, but the higher the density of the goods, the lower this limit is, and for really light load it can also be much longer than 250 km. Once the truck drives longer between natural charging opportunities at the owned chargers, like much regional distribution does it is often good to switch to a charging strategy using public chargers regularly rather than increasing battery size and letting the battery weight reduce the load. For trucks which need regular public charging, it will be important to know if the truck drives a fixed route or not, as only trucks driving the same routes, like truck in shuttle operation, allows using a strategy with contracted or owned public chargers. Another factor determining the suitability of charging strategies is how much of the energy is charged publicly. A high price for public charging is not much of a problem if only a minor fraction of the energy comes from public charging, while charging all energy from expensive public chargers will be prohibitively expensive. When the price for public charging eventually becomes low the amount of public charging used will not be as important for the average charging cost.

Segment	Charging strategy					Explanation
	A	B	C	D	E	
Distribution from own terminal, returns to terminal <250 km Ex.: City distribution						No need for public charging except at disturbances and extreme cases.
Customer-Customer <250 km/day Parked at own depot Ex.: Operates in a limited area						Since the battery will last the whole workday the driving pattern does not matter.
Distribution from own terminal, returns to terminal >250 km Ex.: Regional distribution						Needs public charging. Will not return to own terminal before battery runs out.
Line-haul between own terminals, >250 km fixed routes.						Can use contracted public chargers as they drive predetermined routes.
Customer-Customer >250 km/day Parked at own depot, fixed route Ex: Shuttle operation						Can use contracted public chargers as they drive predetermined routes.
Customer-Customer >250 km/day Park at own depot, varying routes Ex.: Operates within a region						Cannot use contracted public chargers as they drive varying routes.
Customer-Customer Not using a depot, varying routes Ex.: General Long-haul						All charging at public chargers., since the truck does not return to any own depot, not even when parked during night.

Table 3: Preferred charging strategies for some transport segments.

Green=good, Yellow=possible but not proffered, Red=unsuitable strategy.

The range limit of 250 km will vary depending on type of goods, and topography.

Conclusions

Electrification of logistics systems is often viewed as complex and difficult. The purpose of this study was therefore to propose a framework for electrifying logistics systems by combining aspects of the transport market and traffic market (Wandel et al., 1992), i.e. transport segments and charging strategies. The transport segments can be described using seven identified factors, such as distance and number of stops. Using these factors, seven different transport segments were described. The segments ranging from distribution routes less than 250 km originating and returning to own terminal (city distribution) to varying long haul deliveries. Furthermore, the results illustrate how the factors can be linked to electrification and their individual effect on electrification, in terms of enablers and preventers. For the other part of the framework, five charging strategies were presented and the results illustrate the suitability for each charging strategy depending on development phase of public charging infrastructure. The framework shows that electrification of different transport segments is heavily connected to charging strategy, and thus provide indications of which strategy is suitable for which segment. The results thereby have both research and practical implications. Identification of factors to describe transport segments and connect them to electrification, as well as formulating charging strategies and their suitability add important insights to the electrification literature. Furthermore, it shed light on aspects that need to be considered when investigating electrification. For practitioners, the framework provide guidance on which transport segment is most suitable to start electrifying. Future research could expand the framework and including other logistical aspects, such as logistics performance or how type of goods affects charging strategies, i.e. weight or volume limiting goods.

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CONSULTING WITH STAFF ON CHANGE MANAGEMENT INITIATIVES TAKES A LOT OF VALUABLE TIME AND EFFORT – IS THE TOP-DOWN APPROACH TO MANAGING CHANGE NOT EASIER IN THE LONG RUN.

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ABSTRACT

Purpose: The disciplines of organisation development (OD), organisational behaviour (OB) and supply chain management (SCM) share much in terms of the ongoing occurrence of change and how it is facilitated and managed. This paper utilises scenario foresight planning as an instrument of change management through the lens of OD, OB, and SCM. It gives particular emphasis on how the involvement and engagement of the people dimension [human supply chain continuum], contributes to the achievement of satisfactory outcomes. It seeks to outline progression in terms of both research into the fields and business process improvement.

Design/Methodology/approach: The authors commenced an assessment of the relevant literature which informed the scope of their investigation. Having assessed the legacy and contemporary applications of both OD and OB, they then methodically reviewed authoritative textbook publications, and articles in leading SCM and business journals. This enabled identification of the extent and nature of coverage of people involvement in extant literature on systems-wide change management interventions

Findings: This exploratory research identified the extent to which large scale change management interventions are addressed in the leading SCM journals. It also identified the nature of this coverage, thereby allowing the authors to make a number of recommendations for practitioners and researchers.

Research Limitations/implications: The paper proposes a programme for potentially fruitful future research into the issues under investigation.

Practical Implications: The paper makes a number of recommendations aimed at supporting business managers bring change management initiatives to fruitful conclusion.

Originality/value: This work provides a fresh perspective on the people dimension, from a human supply chain continuum [HSCC] perspective in the context of change management and SCM improvement and reengineering.

Keywords: organisation development (OD), organisational behaviour (OB), and supply chain management (SCM), vision for the future, scenarios, human supply chain continuum, uncertainty, systems-wide change management interventions, and resistance to change.

1. Introduction – A Salutory Tale

“I have a story you will find interesting,” said the guest speaker at the Annual Conference of the National Institute of Transport and Logistics, (NITL) in Dublin. Sir Chris Bonington, the famous mountaineer was describing how, having fallen in love with the mountains, he set about developing his skills at rock-climbing. “In my youth I would hitch-hike at weekends to Snowdonia or Scotland with the hope of climbing with anyone who would take me up a rock face.”

Some years later, following a short-service commission as an officer in the British army, he gravitated towards Alpine climbing in the Swiss Alps. In 1962 he was part of the first British ascent of the North Wall of the Eiger. It was there, in Grindelwald, that he sensed the opportunity of making a living from climbing. (Bonington, 2001).

He recounted how, having developed the techniques of snow and ice climbing in the Alps, he had the dream of climbing in the Himalayas. His vision developed into a mission, which became: ‘The 1970 British Annapurna South Face Expedition’. (Bonington C. , 1971)

Bonington told his audience that tackling Annapurna's unclimbed South Face, was going to require siege tactics. The word siege is described as: 'the act or process of surrounding and attacking a fortified place in such a way as to isolate it from help and supplies, for the purpose of lessening the resistance of the defenders and thereby making capture possible.' (Google Scholar. Siege Definition & Meaning | Dictionary.com)

Bonington, the storyteller, used the word siege as a way of drawing his audience into his story. However, he was not attempting to 'surround the mountain, nor force it into submission', instead he was relating a scenario of how he and a number of others attempted to overcome the hostile environment, and dangerous conditions presented by the South Face of Annapurna.

Whilst the NITL audience were appreciative of a good adventure story, the content of the Question & Answer session at the end of his input revealed an understanding of Bonington's blend of managerial style and leadership skills.

1.1 Management and Leadership

So what is the relationship between management and leadership? Mullins [2016] posits the opinion that "Although the two terms are often used interchangeably, management may be viewed as relating to people working within a structured organisation and with prescribed roles, in order to achieve stated objectives ... The emphasis of leadership is on interpersonal behaviour in a broader context. It is often associated with the willing and enthusiastic behaviour of followers. Arguably, there are differences between leadership and management." (Mullins L. , 2016) Leadership may be defined as "influencing the behaviour of others towards the achievement of common goals. (O'Grady, 2001) Bonington's approach could be best described as a 'transformational leadership' style.

Burns (1978) stated that the transformational leader is 'one who treats relationships with followers in terms of motivation and commitment, influencing and inspiring followers to give more than mere compliance to improve organisational performance.' Cited in (Huczynski & Buchanan, 2013)

What also became obvious to Bonington's listeners was, a robust supply chain was required to accomplish the task of leading and managing an expedition to the Himalayas. The single most important factor of his supply chain was people. Not just the lead climbers who would potentially reach the summit of the mountain, but an external and internal supply chain of people, required to make things happen. The commitment of the 'invisible chain of people' was an important factor in the fulfilment of a wide variety of functions. Roles such as the admin team, pre-expedition, purchasing, storage and shipping of travel arrangement, food and equipment. The transport and logistics of the trek into the Himalayas – the chain of porters who carried the food and equipment up through the mountain passes. The base camp team of cooks, medics, the press, and PR. The climbing teams, who set up and supplied the overnight camps on the face of the mountain. And finally, the summit teams of climbers and sherpas.

2. Creating a Vision of the Future.

From experiences gained in his short-service career as an army officer, Bonington recognised the need to create a vision of what he hoped to achieve. He needed an appealing vision, to attract a wide variety of stakeholders. Stakeholder such as: sponsors to finance the project, suppliers (preferably as sponsors) for equipment and provisions, logisticians for transport and travel plans, et cetera. Bonington's goal was to conquer Annapurna's South Face, to do it in safety, and get everyone off the mountain in one piece. His vision generated the desire in others to be part of his great adventure.

Obviously, companies engaged in SCM do not undertake the type of dangerous exploit as envisaged by Bonington. But managers do need to share with their colleagues their vision of what they want to achieve in the future for their company. De Ruijter et al (2014) advises managers of the requirement to construct for the intended audience a "mental image" of a realistic, plausible, and desirable future for the organisation Leaders use this mental image as a power (energy) to fulfil their leadership roles and responsibilities and to inspire others"

Having a knowledge or practical experience of organisation development or organisational behaviour is certainly helpful to the manager who is contemplating a system wide, change management intervention. It would be beneficial, but not a necessary requirement to hold a qualification to perform such a task - knowledge is not knowing information but knowing where to find it. To assist in finding answers to these questions it would be prudent to solicit the services of an experienced change management consultant, often referred to as an OD practitioner or change agent.

3. Using Consultants - with Caution

Eisen (2010) cautions the need to invest time in choosing the consultant. This person should be able to demonstrate a proven ability in the area[s] you wish to develop. They should have a record of accomplishment of time spent “acquiring relevant knowledge and skills, gaining hands-on experience, concerning themselves with professional and personal values, and involving themselves in personal learning process necessary for their development as a professional practitioner ... Developing this further Eisen states that for many practitioners learning the skills of their trade is experiential: “When we observe these professionals early in their careers, we often see at first technicians with a bag of tricks” ... “they reach for an intervention in their bag of tricks that when made has more to do with quietening their personal anxiety than with the here-and-now needs of the client.” Fortunately, the majority of change agents are highly competent at what they do: “when observed at work many of the top OD practitioners effortlessly flow in an unfolding process with their client. (Eisen, 2010).

3.1 Professional Ethics

With regard to professional ethics, Cummings et al., declare that “ethical issues in OD are concerned with how practitioners perform their helping relationship with organisation members. Inherent in any helping relationship is the potential for misconduct and client abuse. To its credit, the field of OD always has shown concern for ethical conduct of its practitioners.” (Cummings, et al., 2020)

4. Scenario Foresight Planning

Albeit it with the assistance of a consultant or in-house support, an initial consultation with all stakeholders is key to the success of any change venture.

This commences the ownership process and is the beginning of ‘Scenario Foresight’ planning. Chermack et al., state that “even among the most prolific writing on scenario [stories], it is difficult to find crisp definitions that capture the true meaning of scenario planning ... the distinguishing factor for scenarios is that they are not predictions or forecasts. Scenarios are not concerned with getting the future ‘right’, they aim at challenging current paradigm of thinking and broadcast a series of stories in which attention is directed to aspects that would have been otherwise overlooked.” (Chermack, et al., 2001) Having identified where you want to be, you now have to construct a scenario for others to understand which direction you want to move to and how you propose to get there.

At this stage, the questions most likely to arise are: Is this the best way, or only way of doing this? Are there alternative approaches to achieve this or that outcome? When we eventually get around to the ‘what would happen if’ question, we should consider looking wider, beyond our immediate surroundings and to take in the bigger picture.

In Bonington’s case, it was doing what had never been done before, that of climbing a high-altitude Himalayan peak, but using the techniques of Alpine rock-climbing to do it! He had the wisdom and foresight to involve people in the planning. He assembled team of specialists, with the expertise and experience of tackling unknown, difficult environments. He actively sought their views, and opinions. He had the wisdom to listened to their perceptive how they would do things. This form of consultation, with highly independent people led to ownership of a shared vision. He created the sense of unity required to tackle a large-scale intervention.

5. Large Scale Change Interventions

In response to the question ‘What are effective interventions?’ Cummings et al., state “Interventions are planned actions and events designed to help an organisation improve its efficiency.” ... designing OD interventions requires “paying careful attention to the needs and dynamics of the change situation and crafting a change programme that will be consistent with the above previously described criteria for effective interventions.” (Cummings, Worley, & Donovan, 2020) further state “The three major criteria that define an effective OD intervention are:

1. the extent to which it fits the needs of the organisation:
2. the degree to which it is based on causal knowledge of intended outcomes: and

3. the extent to which it transfers change management competence to organisation members.”

The importance of ‘transference of change management competence is to organisation members’ is dealt with in later in ‘the people dimension of SCM.

6. Managing change.

For change to take place the need for change must exist and that need is a known as a ‘felt-need’ Change is either evolutionary or revolutionary. Evolutionary change is incremental, it develops over time, with little notice. On the other hand, revolutionary change is sudden, dramatic, and overwhelming, taking people by surprise. Prashant et al., observed that change is ever present in business, in today’s continually changing business environment, often organisations have to change strategic direction, structure and staffing levels to stay competitive (Prashant, Hobman, Jones, Cindy, & and Callan, 2004) A good example is the disruptions caused by Brexit. Brexit turned normalcy in the UK on its head. It would appear that the people driving Brexit assumed any changes incurred through leaving the European Union would be evolutionary. Some change would be involved, but generally business would continue as usual.

Michel Barnier, the EU negotiator for Brexit recorded in his diary, on Monday 17th July 2017: ‘There were six of us around the table. On our side we each had a file in front of us. Strangely, the three British negotiators have come empty-handed.’ Barnier final note of the meeting reads: ‘Clearly, in this negotiation we will have to pay as much attention to the language of gestures as to that of words,’ (Barnier, 2021)

The UK’s Brexit experience was in fact a revolutionary change. It was a complete cessation of the customary way of doing things. The journey was as uncertain as that cited in the poem ‘The Road Not Taken’ published in 1916 by Robert Frost (1874-1963) (Robinson, 2023).

*‘Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveller, long I stood
And looked down one as far as I could
To where it bent in the undergrowth;’*

The Brexit experience in reality, was a long-term exercise involving unprecedented change. For some it was just a matter of ‘get it done’. For many others [both yes and remain voters] it was a fearful experience. A journey into an unknown territory with no experience of what to expect

What Bonington was attempting in terms of Organisation Development [OD] was a systems-wide change management intervention. He, like many business managers and practitioners operating Supply Chain Management (SCM) when taking on an intervention of this magnitude, are venturing into the unknown. Even with the benefit of existing policies or procedures in place, they are still confronted with the task of making decisions based on uncertainties. They may not be the type of life and death decisions taken in the course of climbing expedition, but decisions that important none the less. Decisions that will without doubt have consequential repercussions at some time in the future.

There is a history of leading global companies who did not feel [or see] the need to change. For example: Eastman Kodak failed to engage in the digital era, Motorola was outwitted by smart phones, IBM did not adapt to the demand for personal computers, Dell was overtaken by mobile devices. These and many more became complacent with their product or service, they resisted change and ignored the long view that change is, like it or not, inevitable.

Therefore, if a manager senses the need for change, that is not apparent to others, it is down to the managers to generate a ‘felt-need’, and this can be done through proper planning.

7. Scenario Planning.

Scenario planning is a creative approach to thinking about complicated and unclear futures. Wright et al., (2018) encourages the inclusion of other people in the creation of scenario stories, “scenario development sometimes involves a scenario team composed of representatives from multiple agencies – for example, the scenario team is initially formed from a heterogeneous constituency.”

De Ruijter et al., (2014) were insistent in their view that the purpose of scenarios is to cover possible situations in which the organisation might find itself and over which the organisation has no influence. Scenario stories might describe the external environment but do not involve plans or policies. Schwartz observed that scenarios are stories about the ways the world might turn out tomorrow, stories that can help us recognise and adapt to changing aspects of our present environment. (Schwartz, 1996) Peterson et al., state that the central idea of (using) scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome. (Peterson, Cumming, & Carpenter, 2003)

8. The People Dimension of SCM.

The leadership style and the management skills Bonington described were familiar to the experienced audience of supply chain managers. However, he emphasised the point that it did not matter what task one was attempting to achieve, the critical ingredient is self-belief and a belief in the ability of others.

Central to the success of Bonington's expedition was his approach to managing the Human Chain as first mentioned by the Irish Nobel Literature Laureate, Seamus Heaney in his 2009 anthology of poems. (Heaney, 2011) (Sweeney, 2013). However, a more encompassing description: "The Human Supply Chain Continuum (HSCC) (Glynn 2023) provides perhaps, a fuller description of the engagement of people.

The members of Bonington's team were not only engaged in every aspect of planning and decision making, but in this enterprise, they literally held each other's lives in their hands. Sweeney states that the notion of consulting with people is at variance with many SCM practices, where traditionally there has been a strong emphasis on the hard-wiring with a focus on, for example, technology and systems. This ignores the criticality of (soft wiring) the people dimension. (Sweeney, 2013)

Bonington's primary need was to create an assault team. These would be required to serve as a driving force and provide total engagement and commitment to the enterprise. But this also provided him with a dilemma. This driving force were also his specialist climbers who had technical expertise to accomplish the task. The very people whom he required to work as a team on the ascent of the South Face of Annapurna, were high achievers by temperament and soloists by nature! He therefore needed them to agree to the ultimate goal of getting, through collective effort, as many people as possible (or maybe just one person!) to the top of the mountain.

He reached out to contacts in the climbing world. He wanted [needed] people; who could be trusted, who were not adverse to taking risks, who were practised at finding creative solutions to problems they might encounter. They also had to fit the profile of accomplished, high altitude, mixed ability snow, ice, and rock climbers. And finally, they needed to be agreeable to leaving personal ambition aside, with the agreed understanding that reaching the summit could only be achieved through collaborative effort. Isserman et al., (2008) highlights the necessity to 'have people who are prepared to sacrifice personal ambition to help someone else'.

This applies equally to business, systems wide change. Fortunately, the management of a SCM practice has the advantage of being able to build a 'driving force' of existing employees and supplement it with associated stakeholders. Wright et al., (2018) proposes that "initial consideration of the full range of stakeholders involves eliciting a list of all those individuals and organizations who might either affect or be affected by the unfolding of the focal issue of the scenario project."

A change management intervention requires people with the attributes of being flexible with change. Capable of dealing with complexity and comfortable with circumstances shrouded by uncertainty. Wright et al., addressed this issue and observed that "Aleatory uncertainty is present where probabilities can be attached to potential outcomes based on a priori reasoning or empirical frequencies of specific outcomes in similar events." (Wright, Cairns, O'Brien, & Goodwin, 2018). (Churchman (1968) posited that the existence of uncertainty, in both the present and the future "should be acknowledged and confronted and the approach to tackling the 'wicked' problem should support the design of robust strategies that are intended to perform acceptably whatever the future may bring." Indeed, Ilmola & Rovenskaya (2016 cited by Wright et al., 2018) offered the opinion that "some events fall into the category of 'unknown unknowns' or ontological uncertainties.". Above all, the people needed to be leaders in their own right, but also capable of working collectively. The work of Fawcett et al. (2008) draws a similar conclusion: People are the key bridge to successful collaborative innovation and should therefore not be overlooked as companies invest in supply chain enablers such as, technology, information, and measurement systems. Extending Fawcett's observations a potential extension of The Human Supply Chain Continuum (HSCC) would be the formation of a stakeholders consultative assembly.

9. Stakeholder Consultative Assembly.

From a business perspective stakeholders are everyone who have an interest in the company. A stakeholder assembly of the HSCC, could form an integral part of the consultative process. Wright et al., (2018) proposes that “initial consideration of the full range of stakeholders involves eliciting a list of all those individuals and organizations who might either affect or be affected by the unfolding of the focal issue of the scenario project.”

The consultative process, particularly in relation to a large system change management intervention is fraught with the dilemma of who should be invited to attend. Should it be confined to those who have a financial interest in the well-being of the business, such as shareholders? Or should an invitation be extended to other parties?

Ernst & Young Global Limited [EY] found that “executives see suppliers as being as important as, or more important than, shareholders. Understanding the different stakeholders in their sector can be key for setting the overall strategy. This is not to say that shareholder returns are unimportant.” The EY Global Strategy survey noted that “the shift from “shareholder first” to “stakeholder first” has emerged as a key theme in the 2020 EY Realizing Strategy survey (pdf). Not only are a broader range of leadership roles gaining influence in developing strategy, but strategies developed are increasingly built around long-term goals with a wider range of stakeholders in mind. Where once the primary focus was the shareholder, broader groups including customers, employees, suppliers, and society at large – through environmental and social goals – are gaining importance. (Rath, Khoury, Agarwal, & Shankar, 2021).

10. Resistance to Change

Opposition to change due to lack of consideration given to the people dimension is often cited as a reason why change interventions fail to come to fruition. Resistance to change is a fundamental human reaction to uncertainty. A basic reorganisation of work practices [or even job redesign] can produce significant levels of resistance amongst employees. Similarly, the instinctive reaction by management to oppose resistance can be disastrous, leading to the possibility of both sides becoming entrenched in their point of view. However, it is worth considering that a show of resistance can indicate the depths of emotions staff have for both the company and their jobs. Large scale change interventions invariably lead to change in an organisations culture particularly in relation to attitudes and behaviours. To change attitudes it is first necessary to change behaviour, requiring managers to focus on people-related barriers to change. Getting staff to discuss potential changes and clarifying their attitudes towards the changes is important. Jhangiani et al., propose that: ‘because attitude strength is determined by cognitive accessibility, it is possible to make attitudes stronger by increasing the accessibility of the attitude. This can be done directly by having people think about, express, or discuss their attitudes with others. After people think about their attitudes, talk about them, or just say them out loud, the attitudes they have expressed become strong.’ (Jhangiani, 2022)

The Bonington account of climbing Annapurna’s South Face demonstrated for his audience [and us] that:

- 1) Applied SCM theory and practice is ubiquitous, it reaches beyond the traditional perspective of transport and logistics, into all levels of society.
- 2) Change is an ever-present factor of life. We can be victims of change or proactively make it happen.
- 3) Getting the Human Supply Chain Continuum totally involved in every aspect of the process of change will increase the probability of success.

Areas for improvement relate to many factors, one of which is the approach organisations take to the management of change. Some of these factors are included in this article, but are not limited to:

- Managing change using a methodological approach that its beneficial to both people and the organisation.
- Developing a future [long-term] vision for the organisation, particularly in the case of systems-wide large-scale interventions.
- Creating scenario stories to assist the stakeholders understand the significance of the planned change(s) about to take place.
- Involving the human supply chain continuum from the onset.
- Encouraging all stakeholders to engage in the consultative forums and workshops.
- Inviting, and involving all stakeholders to participate in the strategic conversation.

In addressing these issues this paper has demonstrated the necessity for companies on the whole, and managers in particular to improve their knowledge and understanding of their human supply chain continuum. The fact that some, if not all employees exhibit some form of resistance to change, shows that they care about the company and their future in it.

The top-down approach to managing people, even in the most authoritative structure, is doomed to failure. The reactance generated, and the alienation of staff against any changes imposed will do little to dispel the climate of uncertainty that is bound to arise.

However, a bottom-up approach will bring people on board. Long term scenario planning, where people are engaged and consulted about their future company will alleviate misgivings held and help to avoid mistrust.

The attending question to the title of this paper was:

Is the top-down approach to managing change not easier in the long run?

The research findings would suggest the answer is: Lost!

The final word in this paper goes to Sir Chris Bonington. In his conclusion to an article in the Alpine Journal [1971] he referred to his assault team¹ and observed: 'the remarkable thing on Annapurna was that there was such a level of accord, and that there was the only one serious difference of opinion within the team. It was a healthy one, and the fact that it was brought out at the time and thrashed out acted as an important safety valve to the stress under which we were all labouring.' (Bonington C. , 1971)

1 The Annapurna South Face assault team consisted of 31 people: 10 Face climbers, 8 Sherpas, 6 local porters. 1 Doctor, 1 Base camp manager, 5 T.V. Team, (Bonington C. , 1971) (p.32). Sadly, there was one fatality: Ian Clough (1937-1970) who whilst successful in reaching the top of Annapurna, was lost to the mountain, never to return home.

Glossary of Terms.

Human Supply Chain Continuum (HSCC):

Human Supply Chain Continuum (HSCC) refers to: human engagement, and commitment in all forms of enterprise activity - through recursive, heterogenic, physical involvement, and consultative, intellectual engagement with the processes, contributing and enabling the sustainability of the enterprise. (Glynn 2023)

Organisational Behaviour (OB):

OB is the "study and understanding of individual and group behaviour and patterns of structure in order to help improve organisational performance and effectiveness. (Mullins L. , 2016). "Organisational behaviour is an inter-disciplinary field dedicated to better understanding of management of people at work. The three basic levels of analysis in OB are the individual, the group, and the organisation. The rich heritage has spawned many competing perspectives and theories about human work behaviour. (Buelens & Debussche, 2006).

Organisation Development (OD):

(French & Bell, 1999) define OD as a number of components they consider essential, such as: long-term effort; led and supported by top management; visioning process; empowerment process; ongoing collaborative management of the organizations culture. All of which have resonance today, some twenty years later ... Kenward, (2018) with a more recent definition, expresses alignment with the 'needs of an ever-evolving business climate,' along with a connection with the people in the work force.

OD Interventions:

Rothwell et al., (2010) state that "the purpose of an OD intervention in a large system is to make significant change in the character and performance of the organisation, a stand-alone business unit, or a large department. The character of an organisation includes the pattern of exchanges between the organisation and its environment and the design of the organisation's internal structures, processes, and procedures that produce desired products or services." (Rothwell W. , Stavros, Sullivan, & Sullivan, 2010)

OD Practitioner:

A generic term for people practicing organisation development. These individuals may include managers responsible for developing their organisations or departments, people specialising in OD as a profession. (Cummings, Worley, & Donovan, 2020)

Scenario Foresight Planning:

“Scenario Planning provides leadership teams with an opportunity to explore the business environment holistically by generating a substantial amount of dialogue, creative thinking, brainstorming, and intuition in order to build alternative futures in which statistical forecasting techniques are deemed inadequate due to the extent of environmental uncertainty. On the downside, there is a small amount of literature that alerts us to the shortcomings of using Scenario Planning.” (Oliver, Reid, & Gray, 2022)

Scenario Stories:

Scenario stories are created through using the core uncertainties to develop a hypothetical future. The stories are internally consistent, they allow for value - free judgements. The full list of uncertainties can be used to develop content the content of the stories. Scenario stories are about hypothetical futures, usually three in number. They are internally consistent and allow value - free judgements. They are a method of overcoming personal interests. Scenarios are tools - nothing more, nothing less.

Stakeholder Assembly:

A stakeholder assembly forms an integral part of the scenario foresight planning. Wright et al., (2018) proposes that “initial consideration of the full range of stakeholders involves eliciting a list of all those individuals and organizations who might either affect or be affected by the unfolding of the focal issue of the scenario project.”

Strategic Conversation:

Strategic conversation must perennially challenge the Official Future of the organisation. Even if it comes to pass, the organisation will be stronger, and more resilient, because it has considered alternatives. And in the current global environment, very few organisations will enjoy a long existence within their Official Future. (Schwartz, 1996)

Stakeholder:

Stakeholders are everyone who has an interest in the business. Ernst & Young Global Limited (EY) found that “executives see suppliers as being as important as, or more important than, shareholders ... Where once the primary focus was the shareholder, broader groups including customers, employees, suppliers, and society at large – through environmental and social goals – are gaining importance.

Systems Wide Large-Scale Intervention:

Large scale, systems wide change management interventions, concern the whole of the business and looking at where the business needs to be in 15- or 20-years' time. They should not be confused with the three or even a five-year strategic plan. Such plans generally address contemporary issues, or possible strategies to address problems currently facing the business.

Uncertainty:

Uncertainty is becoming an important factor for business leaders and planners to consider. It is apparent that the ability to come to terms with uncertainty is just as if not more than important now.” (Chermack, Lynham, & Ruona, 2001) ... Peterson et al., suggest that “uncertainty can encourage tolerance because the plans and beliefs of others may turn out to be more effective and correct than your own. And uncertainty can inspire action because the future is not already determined but is being created by the plans and actions of people. (Peterson, Cumming, & Carpenter, 2003)

Vision of the Future:

Schwartz speaking about ‘scenario’ suggests that they are “a set of organized ways for us to dream effectively about our own future. Concretely, they resembled a set of stories, either written out or often spoken. However: these stories are built around carefully constructed plots that make the significant elements of the world scene stand out boldly. (Schwartz, 1996)

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THE SOCIO-ECONOMIC EFFECTS OF THE 3FM PROJECT ON IRELAND

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Introduction

In the current era of heightened environmental consciousness, the relationship between ports and socio-economic development has taken on a renewed significance. Expanding and operating ports can have significant socio-economic effects on the surrounding communities and the national level. The negative externalities stem from the expansion and development of ports, while the positive externalities emerge from the transformation and evolution of traditional ports into commercial locations or commercial clusters.

On the detrimental side, the negative externalities of port activities, such as air, water, and noise pollution caused by port operations and disruption of ecosystems or even unequal economic benefit distribution among the regional communities (EPA, 2023, Ducruet et al., 2021), can have adverse effects on the socio-economic well-being of local residents (Hidalgo-Gallego and Nunez Sanchez, 2023; Ducruet et al., 2021). Moreover, there are potential debates surrounding the most effective allocation of national resources to key sectors (UN, 1987). This concern holds particular relevance to Ireland (Government of Ireland, 2021, Stavrou, 2023). Potential contentions exist regarding the optimal distribution of national resources towards main sectors (UN, 1987), such as the housing domain in the context of Ireland and the development of the port of Dublin.

On the beneficial side, ports play a crucial role in facilitating international trade and commerce, serve as vital gateways for imports and exports, mitigating economic disparities (Bottasso et al., 2014), supporting economic growth, job creation (Hidalgo-Gallego and Nunez Sanchez, 2023), and revenue generation. They can stimulate local and regional economies by attracting business investments, fostering employment opportunities, and contributing to tax revenues (Rodrigue and Notteboom, 2022; Nazemzadeh, 2016).

This research, examines the effect of implementing the Third and Final Master plan (3FM) port development project on socio-economic factors, including its impact on GDP, total employment, and environmental issues for Ireland.

Literature review

Port development and socio-economic effects

In the realm of economic growth literature, there exists a multitude of opinions regarding the impact of infrastructure and infrastructure investment on economic growth and socio-economic factors. However, a definitive and universally accepted conclusion remains elusive.”

When empirically investigating the relationship between transport infrastructure and economic growth, it is essential to consider several key issues and ambiguities that have emerged from prior studies (e.g. Meersman and Nazemzadeh, 2017; The White House, 2014; Iacono, 2013; Ferrari et al., 2012; Égert et al., 2004; 2008; Lakshmanan, 2007; Graham, 2007; Lakshmanan and Chatterjee, 2005; Fujimura, 2004; Kawakami and Doi, 2004; Roller and Waverman, 1996; Aschauer, 1989) and can be classified as following:

- 1 Non-Direct and Multidirectional Influence: The impact of transport infrastructure development on economic growth and socio-economic factors is not necessarily a direct and unidirectional relationship. Instead, there are indications that transport infrastructure affects international trade, which, in turn, influences economic growth. The resulting economic growth can generate funds for further expansion of transport infrastructure, creating a complex interplay of factors.
- 2 Diverse Empirical Growth Models: A plethora of empirical growth models exist, exhibiting significant variations in the explanatory variables employed. Consequently, divergent conclusions emerge concerning the impact of transport infrastructure investment. The substantial heterogeneity among these models underscores the importance of selecting appropriate explanatory variables and exercising caution when interpreting results.

- 3 Differential Effects in Developing and Developed Economies: The anticipated impact of infrastructure on economic growth is expected to be more pronounced in developing economies compared to developed economies. Socio-economic factors and economic growth possibly be triggered by ground-breaking innovations or large-scale developments in developed countries.
- 4 Long-Term Focus: It is suggested that the impact of transport infrastructure on economic growth manifests predominantly in the long rather than in the short run. Consequently, temporal considerations are vital in assessing the relationship between transport infrastructure and economic growth.
- 5 Influence of Methodological Factors: Empirical investigations into the relationship between transport infrastructure and economic growth are influenced by various methodological factors. These include data availability, the selection of variables, the degree of disaggregation, and the statistical methods employed. These methodological choices can significantly shape the outcomes of empirical analyses.

These factors warrant careful attention and thoughtful consideration to ensure a comprehensive analysis of the relationship.

As ports transform into value-adding industrial hubs and play a vital role in national development (Nijdam et al., 2018; Nazemzadeh, 2016; Brooks et al., 2007), the aim of this research is to investigate the influence of the launch of the 3FM project in Port of Dublin on Ireland's socio-economic factors at a national level, while considering the complexities identified above regarding the contribution of transport infrastructure development to the national economy. In Ireland, the direct and indirect maritime sector contribution to the country's Gross Domestic Product (GDP) was approximately 2% in 2018 (SEMRU, 2019). However, when comparing this figure to other countries with similar geographical conditions, it becomes apparent that Ireland has the potential for further growth in its maritime sector's contribution to the national economy. For instance, Belgium, with a comparable geographical situation, recorded a maritime sector contribution of 7% in 2020 (Rubbrecht, 2022), while the Netherlands reported 6.6% in 2021 (Buitendijk, 2023). Despite its distinct characteristics, Singapore achieved a notable 7% maritime sector contribution in 2019 (Turner, 2019). These figures highlight the scope for Ireland to enhance its maritime sector's impact on the national economy. It is essential for economies like Ireland to recognize the economic viability of trading ports and abandon the 'seabind' mindset (Bueger and Edmunds, 2017). Considering Ireland's extensive coastline, strategic location, and historical connections to maritime trade, there exists untapped potential for further development and expansion in its maritime sector. Leveraging these advantages, Ireland can pursue initiatives to bolster port infrastructure, enhancing logistics capabilities, attracting shipping lines, and fostering innovation in maritime-related industries in a balance with environmental protection and sustainable development.

3FM project introduction: its development plan and pros and cons of it:

Dublin Port Company has initiated public consultation for the 3FM - the third and final Masterplan project- the final stage of Dublin Port's development, aiming to reach full capacity by 2040. This project focuses on the Poolbeg Peninsula and will contribute 20% of the required capacity. It includes the development of Ireland's largest container terminal, featuring 650 meters of new berths, with an export area of 9.1 hectares (Area N) and an import yard of 5.9 hectares (Area O). This terminal will boast an annual capacity to handle 353,000 units (equivalent to 600,000 TEU which is 90% increase of the current capacity), surpassing the container volume handled in all other ports nationwide last year by more than two-fold. (DPC, 2023).

Pros and Cons of the 3FM Project in the Port of Dublin

While the 3FM project is expected to deliver significant benefits to the Port of Dublin and the wider Irish economy, there are concerns about its potential impact on the environment, traffic congestion, and quality of life in the area:

- Critics have voiced environmental concerns regarding the 3FM project, focusing on potential air and noise pollution. The project has encountered opposition from residents of Sandymount, a Dublin suburb, who express apprehension about its impact on the local environment and overall quality of life (McGee, 2023)."
- Another concern directed towards the project is favoring road freight over rail, with the Irish Minister for the Environment deeming this approach unsustainable (Nova, 2023; The Journal, 2023).
- Its potential contribution to local traffic congestion is another issue of this project. Residents have expressed concerns that the increased traffic associated with the project could worsen existing traffic issues (McGee, 2023).

Despite addressing the project's drawbacks, it is essential to acknowledge its merits. The 3FM project is expected to deliver significant benefits to the Port of Dublin and the wider Irish economy, including increased capacity, improved efficiency, and new job creation:

- The 3FM project could help to support economic growth and development in the region and create new jobs and support existing employment in the region, which could have positive economic impacts (DPC, 2023; Nevin, 2023; Nova, 2023; Port Technology International, 2021).
- The project includes the development of a new Ro-Ro terminal, which could help to improve the efficiency and effectiveness of freight transport in the region (Nevin, 2023).
- The 3FM project includes the creation of new public parks on the Poolbeg Peninsula, which could have positive environmental and social impacts (DPC, 2023).

In the light of the aforementioned advantages and disadvantages associated with the 3FM project, our study seeks to examine the impact of increased containers handling capacity of this project on the GDP, total employment, and carbon emission of Ireland by utilizing a VAR model.

Methodology and modelling

To analyze the impact of transport infrastructure on economic activities and socio-economic factors multiple empirical methods could be applied. Goetz (2011) has provided an overview of these methods in macro and micro categorize. Another comprehensive overview on the subject is provided by Tong et al. (2014), who offers valuable insights into recent research concerning the interplay between economic activity and transport infrastructure. Their work highlights the need for a simultaneous modelling approach to account for the potential feedback loop among economic activity, international trade, and transport infrastructure. To effectively capture these interconnected relationships, a suitable methodology is the utilization of a Vector Autoregression (VAR) model. VAR models not only enable the testing of feedback effects but also require minimal reliance on existing theories, making them well-suited for analyzing contemporary topics with limited theoretical support (Pesaran and Shin, 1996).

Initially other relevant variables such as transport sector employment, trade, and openness degree were considered, but a few of them did not appear with a significant impact and some other of the variables were highly correlated resulting in unreliable and illogical estimates. As a result, this analysis focuses on key variables such as GDP (economic output), EMPL (total employment), TEU (Port Capacity), Environmental pollution CAR (Carbon Emission of transport sector) as the primary factors of interest. The applied VAR-model looks as follows:

$$X_t = \alpha_0 + \alpha Z_t + \sum_{i=1}^k \beta_i X_{t-1} + \varepsilon_t$$

Where X_t is a vector containing (lnGDP_t, lnEMPL_t, lnCAR_t, lnTEU_t), α_0 is a vector of constants, Z_t is a vector of the exogenous variables including a trend variable (TEU, lnEMPL, lnCarbon), α is a matrix of coefficients, β_i are matrices of coefficients, and ε_t is vector of innovations. We estimated a VAR with log TEU, log GDP, log EMPL, and lag CAR and an optimum lag of 1 year (see Table 1) for the period of 2000-2021.

Table 1 - VAR Lag Order Selection Criteria

Endogenous variables: LOG_TEU LOG_EMPL LOG_CARBON LOG_GDP						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	117.9399	NA	1.32e-10	-11.39399	-11.19484	-11.35511
1	174.1624	84.33383*	2.48e-12	-15.41624	-14.42051*	-15.22187
2	194.0325	21.85704	2.13e-12*	-15.80325*	-14.01093	-15.45337*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						

Analysing and Discussion

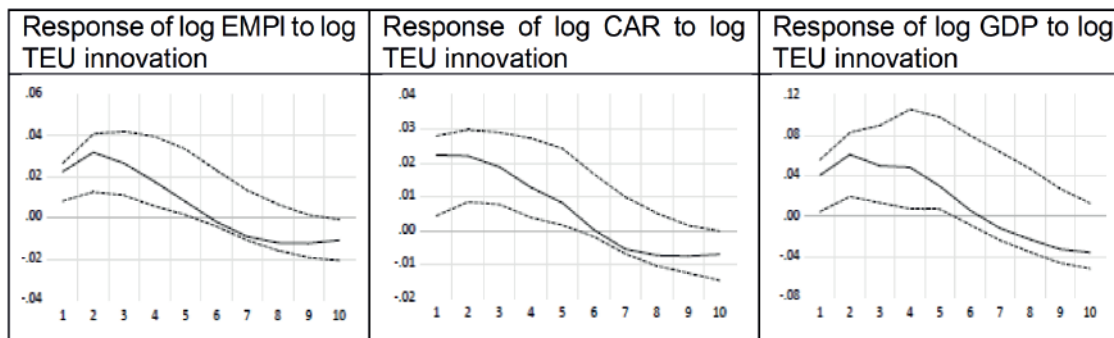
Based on the results of the stability condition assessment and residual autocorrelation tests, that appear to be satisfactory (see Table 2) it is deemed acceptable to proceed with Impulse Response Function (IRF) analysis.

Table 2- Stationary test: Roots of Characteristic Polynomial”

Endogenous variables: LOG_TEU, LOG_EMPL, LOG_CARBON, LOG_GDP	
Root	Modulus
0.971417	0.971417
0.798294 - 0.371196i	0.880375
0.798294 + 0.371196i	0.880375
-0.135967 - 0.763600i	0.775610
-0.135967 + 0.763600i	0.775610
0.361738 - 0.378000i	0.523201
0.361738 + 0.378000i	0.523201
-0.511191	0.511191
No root lies outside the unit circle: VAR satisfies the stability condition	

A 68% confidence interval derived from the application of generalized Impulse Response Function (IRF) analysis- which is not sensitive to the ordering of variables in the VAR- is employed in this study. Figure 1 shows response of log GDP, log EMPL, and lag CAR to a positive shock in log TEU.

Figure 1- Response of log GDP, log EMPL, and lag CAR to a positive shock in log TEU



The Impulse Response Function (IRF) analysis reveals a consistent positive response from all variables to a positive shock in TEU. Specifically, both employment and carbon emissions demonstrate a sustained positive response for a period of 5 periods, after which the response becomes statistically insignificant. Similarly, GDP exhibits a positive response that extends for 6 periods before diminishing in significance. The findings from the variance decomposition analysis indicate the significant influence of increased TEU (Twenty-Foot Equivalent Unit) capacity on both employment (logEMPL) and carbon emissions (logCAR). Specifically, in the initial period following the shock of increased TEU capacity, approximately 81.04% of changes in logEMPL can be attributed to changes in logTEU. Over a 10-year span, this percentage decreases to 69.25%, suggesting the sustained impact of TEU capacity on employment growth. Furthermore, self-interplay within the employment variable accounts for a portion ranging from 18.95% to 22.36% of changes in logEMPL. Notably, a substantial proportion of the increase in logCAR (from 47.01% initially to 61.47% over the investigation period) can be explained by the shock in increased TEU capacity. This highlights the detrimental effect of expanding TEU capacity on environmental factors.

Interestingly, the contribution of increased GDP to carbon emissions (logCAR) is minimal, ranging from 0% to 4.49% by the end of the investigation period. The percentage of changes in logGDP explained by changes in logTEU decreases from 39.44% to 21.03% over time. Nonetheless, this decline still represents a significant factor to consider in the relationship between GDP growth, total employment, and carbon emissions. Based on these results, it is crucial to implement policies and measures that address the harmful environmental effects of increased TEU capacity. Balancing economic growth with environmental sustainability necessitates careful consideration of the significant role played by TEU capacity in both employment and carbon emissions.

Table 3- Variance Decomposition Analysis of logEMPL, logCAR, and logGDP in the 1-10 Period Following TEU Shock

Variance decomposition of logEMPL				Variance decomposition of logCAR				Variance decomposition of logGDP			
LOG_TEU	LOG_EMPL	LOG_CAR	LOG_GDP	LOG_TEU	LOG_EMPL	LOG_CAR	LOG_GDP	LOG_TEU	LOG_EMPL	LOG_CAR	LOG_GDP
81.04572	18.95428	0.000000	0.000000	47.01018	10.07986	42.90995	0.000000	39.44062	0.571728	9.184541	50.80312
86.72098	12.99713	0.018171	0.263720	62.68555	7.768676	29.53159	0.014185	53.86914	0.253785	10.87190	35.00517
83.26867	14.92718	0.879962	0.924182	67.94642	7.556917	23.58740	0.909255	41.80580	9.599291	14.25787	34.33704
75.66357	20.64727	1.089475	2.599692	65.24295	13.70501	20.24315	0.808890	33.99818	17.73945	11.21303	37.04933
70.29458	23.99547	1.456566	4.253384	63.55444	16.21333	19.31631	0.915921	28.37023	18.79315	13.91689	38.91972
68.06776	24.57017	2.676802	4.685264	63.27148	16.33469	19.36852	1.025317	23.91428	18.85435	18.68542	38.54595
67.73111	23.94055	3.755000	4.573340	63.22399	16.03861	19.08399	1.653418	21.16661	19.17121	21.22003	38.44216
68.61541	23.01541	3.972751	4.396424	63.51575	15.60470	18.68089	2.198663	20.14594	18.50123	22.71929	38.63354
69.29050	22.52446	3.896272	4.288772	62.93566	15.79074	18.17169	3.101916	20.33579	17.29340	24.36615	38.00466
69.25569	22.63947	3.759267	4.345567	61.47295	16.53614	17.49319	4.497718	21.03429	16.29736	25.41767	37.25068

However, the model in this study is employed under specific certain conditions, independent of other influencing factors that could aid in managing and controlling carbon emissions. Given that a significant portion of the country's traffic, handled by the Port of Dublin, relies heavily on truck transportation (The Journal, 2023), prioritizing sustainable transport modes, such as investing in rail transport, is crucial. Additionally, potential solutions involve implementing innovative technologies like "Ocean-based green energy technologies," which encompass low- or zero-carbon biofuels, hydrogen (IEA, 2023; Economist Impact, 2021), as well as "offshore wind," wave, and tidal stream power, which offer substantial potential for impact (Economist Impact, 2021). Other potential solutions to be considered encompass port-based incentive schemes (OECD, 2018), implementing pollution prevention methods at construction sites (Marsh, 2022), and fostering collaboration with stakeholders (Economist Impact, 2021). It is important to acknowledge that the 3EM project also faces controversial issues such as housing and the allocation of national resources, but these matters lie outside the scope of this study.

Conclusion

The analysis highlights the significant influence of increased TEU capacity on employment and carbon emissions. The findings indicate the sustained impact of TEU capacity on employment growth over time. However, the increase in carbon emissions underscores the need for proactive measures. Policymakers should prioritize sustainable transport modes, such as rail transport, and adopt innovative technologies like ocean-based green energy. Additionally, implementing port-based incentive schemes and pollution prevention methods can mitigate environmental impacts. Addressing these challenges is crucial for balancing economic growth with sustainability. Looking ahead, policymakers must carefully consider the trade-off between economic development and environmental concerns to ensure a sustainable future for the 3FM project.

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AN ACADEMIC LITERATURE REVIEW OF PERFORMANCE EVALUATION INDICATORS AND METHODS OF TEMPERATURE-CONTROLLED SUPPLY CHAINS

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Introduction

Performance measurement systems and metrics are crucial to businesses and supply chains due to their prominent role in the implementation of supply chain management (Laihonen and Pekkola, 2016, Van Hoek, 1998). A well-defined performance measurement system and metrics support the formulation of objectives, the evaluation of performance, and the determination of future courses of action at the strategic, tactical, and operational levels (Gunasekaran et al., 2015). However, different performance measurement methods and metric designs have varying degrees of success in achieving these aims (Hanson et al., 2011). As a result, it is essential to comprehend how supply chain performance measurement methods and metrics are developed and how they change over time when used as a supply chain practice. In addition, investigating performance measurement systems and metrics in a supply chain is appropriate because it can expand current knowledge on the design, implementation, use, and reflection of metrics and systems (Hald and Mouritsen, 2018). Nevertheless, conventional supply chain performance measurement systems and metrics pay insufficient attention to products that require specialized equipment and facilities for transportation, storage, and distribution, such as Temperature-Controlled Supply Chain (TCSC) systems (Shabani et al., 2012). Consequently, measuring the performance of TCSC is challenging because they differ from other types of supply chains such as shelf-life constraints, seasonality in production, production throughput time, refrigerated transportation and storage requirements, traceability, product quality, and reliability (Aramyan et al., 2007, Mangina and Vlachos, 2005). A review of the existing stock of research on TCSC will be considered the first step in investigating the performance measurement methods and metrics of TCSC. Several evaluations have been released in the previous fifteen years that offer an overview of major TCSC concerns. However, these reviews focus on a specific country (Han et al., 2021a, Mercier et al., 2018, Deng et al., 2012), specific product (Awad et al., 2020, Mercier et al., 2018, Utomo et al., 2018, Shashi et al., 2018), a single stage of the cold chain (Awad et al., 2020, Fan et al., 2020), specific technology (Zhu et al., 2019), and single method (Utomo et al., 2018). Thus, the primary aim of this systematic review is to map current research on metrics and methods of assessing TCSC performance, identify research gaps that need to be filled, and build a conceptual framework.

Review Methodology

Review approach

A systematic literature review approach was used to gather and review the relevant studies addressing the performance of TCSC. This approach was selected because it is becoming an evidence-based original research work (Meerpohl et al., 2012) and an effective method designed to discuss a body of knowledge under study and suggest future research focus.

Material search strategy

For the systematic search, we developed a search strategy that is tailored to four databases; Scopus, Web of Science, Business Resource Complete, and Science Direct to identify relevant literature. We have used different key words and search string such as "Temperature Controlled Supply Chain" OR "Cool Chain" OR "Cold Chain"; "Temperature-Controlled" "OR "Cool Chain" OR "Cold Chain" AND "Performance" to search relevant publications. As a result, we found a total of 1,215 papers from the four databases in the initial search process.

Screening and selection criteria

The screening criteria mainly focused on mapping existing literature on the performance of TCSC in different areas of study. The selection of the relevant work was based on explicit inclusion and exclusion criteria developed by the researchers. We have evaluated the collected materials from the initial search and finally 75 relevant publications from the 1,125 total publications that include journal articles and conference proceedings were selected for analysis.

Analysis and Synthesis

After assuring the quality and precision of the identified papers, a quantitative pooling of data and qualitative synthesis were conducted. In addition, an analysis was made using descriptive and thematic analysis approach.

Findings of the study

Descriptive analysis

Tranfield (Tranfield et al., 2003) and Tranfield & Denyer (Denyer and Tranfield, 2009) recommend the use of data extraction forms, which should contain general information about the paper, such as year of publication, document type, and other specific characteristics that help to make descriptive analysis.

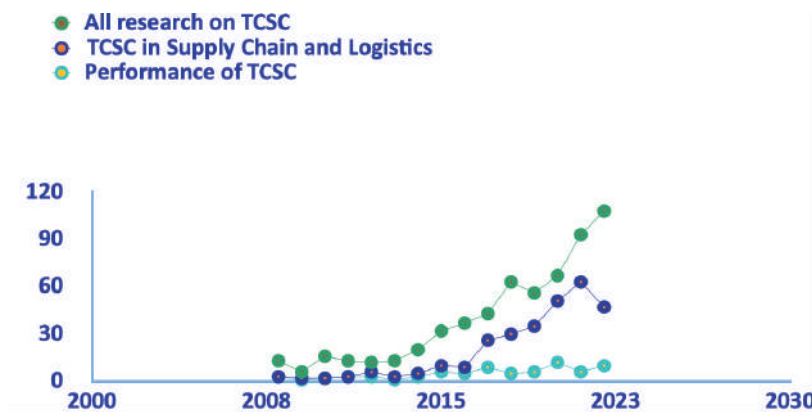


Figure 1 Year of publication (Source: authors)

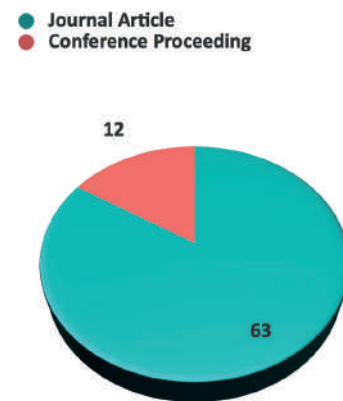


Figure 2 Document type (Source: authors)

75 papers were included, of which 63 were journal articles and 12 were conference proceedings collected from the four identified sources. The temporal distribution of identified papers focusing on the TCSC over the past fifteen years reveals an increasing pattern of change. Even though the number of publications during the first five years was relatively low, there was a notable increase in the number of identified TCSC related publications and similar patterns of change. During the initial years, from 2008 to 2013, the number of publications was relatively low. However, the subsequent years demonstrate an increase in the publication of research on TCSC in all disciplines, including supply chain and logistics. However, except for 2020 and 2022, as depicted in Figure 1 above, the total number of annual publications on performance of TCSC remained below ten. This finding highlighted the need for additional research into the performance measurement of TCSC.

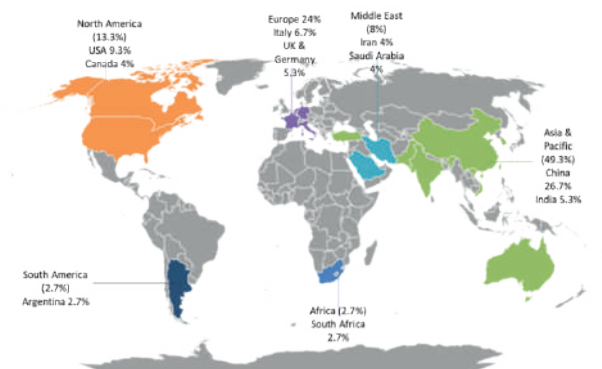


Figure 3 Geographic distribution of papers (Source: authors)

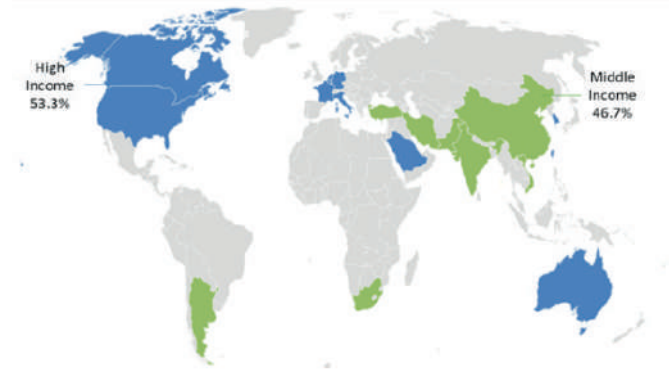


Figure 4 Level of income of countries

Figure 3 and 4 depicts the context of the research reported in the identified literature and the studies were split into geographical location and income level of the countries ranked by the world Bank. This geographical and income level categorization is important because empirical data suggests that the performance of TCSC may vary owing to different geographical location or different level of economic development. For example, variations in geographical location and economic development results variation in weather and infrastructure respectively that determines the TCSC. Accordingly, based on geographical location, Asia & Pacific (49.3%), Europe (24%), and North America (13.3%) were the regions attracting a higher research focus on TSCS. In terms of nations, most frequently studies (26.7%) were in China, followed by USA and Italy recording 9.3% and 6.7% of the total papers respectively. Countries like the UK, Germany, India, and Taiwan recorded a 5.3% of the total papers each. According to (Shukla and Jharkharia, 2013) the advanced infrastructure in place, the availability of funds, customer awareness and the most important consolidation of the food organization in developed countries have created the desired research environment that is seriously lacking in developing countries where there is a lack of customer-oriented research funded by food organizations. At the same time, our research based on the level of income of countries shows that research on TCSC performance over the past fifteen years has paid much of its attention to high-income countries (53.3%) and middle-income countries (46.7%) demonstrating that no paper has been published in low-income countries. This empirical evidence indicates that the field of TCSC has not yet been explored in developing countries.

Thematic analysis

The studies of TCSC performance were conducted in different stages of the supply chain, sector, and product categories. The content analysis of the 75 extracted papers enabled us to provide a detailed overview of the performance of TCSC approaching from different categories. The identified studies were then categorized into stage of the supply chain the study conducted, methods employed, main theme of the studies, and performance metrics used because the performance measurement method and metric used in TCSC varies across different scope of the supply chain, and the main theme under study.

Table 1 Distribution of papers by themes and stage of supply chain

Theme	Stage of Supply Chain	Count
Route and Schedule Optimization	Distribution, Transportation, Supply Chain	21
Performance Evaluation	Storage, Transport, Packaging, Distribution, Supply Chain	19
Transport and Logistics Optimization	Distribution, Transport, Storage	16
Sustainability	Distribution, Transport, Packaging, Storage, TCS,	10
Inventory and Storage Optimization	Packaging, Storage, Distribution	9

The research theme of TCSC varies in different scope or stage of the supply chain. The scope of the research identified ranges from a single stage like packaging, storage up to the whole supply chain. Accordingly, themes examined in each stage of the supply chain are different. As it is shown in the above table, route and schedule optimization was the most (21 papers) researched theme in the distribution, transportation, and the entire supply chain. The second mostly researched theme was performance evaluation (19 papers) followed by transport and logistics optimization (16 papers). Sustainability, contemporary issue across different fields, is also one of the themes (10 papers) researched in different stages of the supply chain by the selected papers. Furthermore, 9 papers from the sampled studies mentioned inventory and storage optimization as the main theme of their studies. Moreover, optimization in different stages of the supply chain were also raised in different topics such as distribution and network, transport and logistics, cold chain, and inventory and storage.

Research Type	Method	Metrics Categories	Count
Analytical research	Mathematical Modeling	Cost, Energy Consumption & Emission, Quality & Safety, Temperature & Humidity, Shelf life, Waste & Damage, Turn over & Profit	44
	Simulation	Cost, Energy Consumption & Emission, Quality & Safety, Temperature & Humidity, Shelf life, Waste & Damage, Turn over & Profit, Service Level and Customer Satisfaction	12
Empirical research	Survey	Cost, Energy Consumption & Emission, Quality & Safety, Temperature & Humidity, Shelf life, Waste & Damage, Turn over & Profit, Information & Traceability, Innovativeness	8
	Experiment	Cost, Energy Consumption & Emission, Quality & Safety, Temperature & Humidity, Shelf life, Waste & Damage, Turn over & Profit, Efficiency & Flexibility, Information & Traceability, Innovativeness	8
	Case study	Cost, Energy Consumption & Emission, Quality & Safety, Temperature & Humidity, Shelf life, Waste & Damage, Turn over & Profit, Efficiency & Flexibility, Information & Traceability, Innovativeness	3

Table 2 Distribution of papers by research type, method, and performance metrics

Research in the performance measurement of supply chain follow different research approaches and methods. The identified papers have employed different methods to study the performance of the TCSC. The selected studies were classified into two broad categories based on the research type and method. Most of studies (56 papers) were analytical type of research and the remaining 19 papers were empirical research. The analytical papers have employed different methods to measure the performance. Accordingly, majority (44 papers) of the analytical papers used mathematical modeling as a method and metrics such as cost, energy consumption & emission, quality & safety, temperature & humidity, shelf life, waste & damage, turnover & profit to measure the performance of the TCSC. Publications that employ a simulation method (12 papers) have used performance metrics such as cost, energy consumption & emission, quality & safety, temperature & humidity, shelf life, waste & damage, turnover & profit, efficiency & flexibility, service level and customer satisfaction to measure the performance of TCSC. On the other hand, 19 empirical papers have employed survey, experiment, and case study methods using similar performance metrics and additional metrics such as efficiency & flexibility, information & traceability, and innovativeness to measure the performance of TCSC.

Supply chain performance measurement methods and metrics is an important topic for both practitioners and academia. It enables the tracking and tracing of effectiveness and efficiency failures and leads to more informed decision making about chain design (Singh et al., 2018). The following discussions attempt to review the various metrics used by the selected papers to measure the performance of TCSC.

Table 3 Distribution of papers by performance metrics

Rank	Metrics	Count	Reference
1	Cost	36	(Wu et al., 2022b, Accorsi et al., 2017, Khan et al., 2021, Liang et al., 2018, Joshi et al., 2011, Garcia et al., 2012, Li et al., 2019, Wang et al., 2020, Fattahi et al., 2013, Leng et al., 2020b, Khan et al., 2020, Andoh and Yu, 2022, Muriana, 2016, Zhao et al., 2020a, Joshi and Banwet, 2015, Mejjaoui and Babiceanu, 2018, East and Smale, 2008, Leng et al., 2020a, Fang et al., 2018, Zhao et al., 2020b, Muriana, 2015, Marchi et al., 2020, Meneghetti and Monti, 2015, Li and Li, 2022, Zhang et al., 2019a, Zhang et al., 2021, Song et al., 2020, Orjuela-Castro et al., 2017, Dabbene et al., 2008, Wang and Wen, 2020, Li et al., 2020, Joshi et al., 2012, Wu et al., 2022a, Hertog et al., 2014, Kaviyani-Charati et al., 2022, Theophilus et al., 2021)
2	Energy consumption and emission	23	(Accorsi et al., 2017, Leng et al., 2020a, Khan et al., 2020, Andoh and Yu, 2022, La Scalia et al., 2017, Marchi and Zanoni, 2022, Zhao et al., 2020a, Zhu and Zhou, 2019, Kumar et al., 2022, Fang et al., 2018, Marchi et al., 2020, Chaomuang et al., 2017, Meneghetti and Monti, 2015, Defraeye et al., 2016, Zhang et al., 2021, Song et al., 2020, Wang and Wen, 2020, Li et al., 2020, Qi and Hu, 2020, Zhang et al., 2019b, Stellingwerf et al., 2018, La Scalia et al., 2019, Kaviyani-Charati et al., 2022)
3	Temperature and humidity	23	(Shabani et al., 2012, Muriana, 2016, La Scalia et al., 2017, Marchi and Zanoni, 2022, East and Smale, 2008, Zhu and Zhou, 2019, Chaomuang et al., 2017, Wu et al., 2017, Cevoli and Fabbri, 2017, Emenike et al., 2016, Huang and Piontek, 2017, Defraeye et al., 2016, Turan and Ozturkoglu, 2022, Dabbene et al., 2008, Wu et al., 2015, Nga et al., 2011, Rattanakaran et al., 2021, Jedermann et al., 2014, La Scalia et al., 2019, Hertog et al., 2014, Aiello et al., 2012, Lang et al., 2011, East et al., 2008)
4	Quality and Safety	22	(Khan et al., 2021, Wang et al., 2022, Joshi et al., 2011, Garcia et al., 2012, Fattahi et al., 2013, Sciortino et al., 2016, La Scalia et al., 2017, Marchi and Zanoni, 2022, Joshi and Banwet, 2015, Zhu and Zhou, 2019, Leng et al., 2020b, Chen, 2015, Osorio et al., 2017, Defraeye et al., 2016, Orjuela-Castro et al., 2017, Wu et al., 2022a, Jedermann et al., 2014, Hertog et al., 2014, Aiello et al., 2012, Lang et al., 2011, East et al., 2008, Yan et al., 2022)
5	Shelf life	10	(Shabani et al., 2012, Sciortino et al., 2016, Muriana, 2015, Muriana, 2016, La Scalia et al., 2017, Nga et al., 2011, Jedermann et al., 2014, La Scalia et al., 2019, Hertog et al., 2014, Aiello et al., 2012)
6	Waste and damage	9	(Zhang et al., 2021, Muriana, 2016, Qi and Hu, 2020, Zhu et al., 2021, La Scalia et al., 2019, Hertog et al., 2014, Theophilus et al., 2021, Yan et al., 2022)
7	Service level and customer satisfaction	8	(Joshi et al., 2011, Fattahi et al., 2013, Zhao et al., 2020b, Joshi and Banwet, 2015, Zhu and Zhou, 2019, Orjuela-Castro et al., 2017, Wang and Wen, 2020, Joshi et al., 2012)

The study has tried to extract the performance metrics of TCSC used by the identified papers in different stages of the supply chain, product category and research themes to enable frequency ranking and evaluated the effectiveness of the metrics. Table 4 above reports top 7 metrics categories used from the 75 reviewed papers in descending order of frequency rank, that includes cost; energy consumption and emission; temperature and humidity; quality and safety; shelf life; and waste and damage. The most frequently used performance metrics is cost (36 papers) that includes all direct and indirect costs of the TCSC. Besides, energy consumption (23 papers) and temperature (23 papers) were two other fundamental performance metrics extensively used to measure the performance of TCSC. The TCSC is more used to manage the flow of perishable products that require a special control of the temperature; accordingly, quality and shelf life were ranked 5th and 6th because the performance of the TCSC can be potentially measure using the quality and shelf life of the perishable products.

Furthermore, service level and customer satisfaction were customer focused metrics that have attracted the attention of researchers. Finally, the performance metrics used in the identified papers were not limited to the above-mentioned metrics rather different additional metrics includes flexibility, traceability, efficiency, innovativeness, travel distance and time, etc. have been used to measure the performance of TCSC.

The difficulty of performance measurement in TCSC was that a wide diversity of metrics has been used to measure performance even for similar products and stages of the suppl chain. Our review also witnessed that several metrics of performance for different products and stages of supply chain were used that showed there is lack of stability on the metrics of performance measurement. Different researchers mentioned different causes for lack of stability or change in the metrics of supply chain. According (Hald and Mouritsen, 2018) technical challenges, alignment, attitude and commitment, conflict and objection were identified as the main explanation for lack of stability in performance measurement system in supply chain. These explanations can also apply to the performance metrics. From the ranked metrics of performance measurement identified by this review, measuring performance of TCSC using service level and customer satisfaction could be more technically challenging because it is very complex to measure and trace the customer satisfaction service level in all stages of TCSC. The other explanation is lack of alignment, as it can be seen from our finding, the performance metrics used at different stages of TCSC are diverse and many in number. Moreover, actors of the supply chain may lack interest in some performance metrics and thus they lack commitment to share information relevant to the specific metrics. Furthermore, metrics such as temperature and cost may have a conflict because to keep the temperature cool energy need to be used and thus cost of energy will raise.

Conclusion

From the overall analysis of the temporal distribution and trends of published studies. It can be learned that the research interest on performance measurement in TCSC gets more attention in the last five years. The reason for such increase could be the global market for perishable goods such as cooled and processed foods in growing due to changing lifestyle (Han et al., 2021b). From a geographic and income level distribution of the publication, a major trend in this field is gradually tending to high-income and middle-income countries, this shows that though the low-income countries are known in agricultural products, research on measuring the performance of TCSC in these countries lacks proper attention.

In the review of the sampled papers, the scope of the research ranges from a single stage like packaging, storage, transportation, distribution, up to the whole supply chain. The research of performance measurement in TCSC has tried to evaluate the performance using different themes such as route and schedule optimization, performance evaluation, transportation and logistics optimization, sustainability, and inventory and storage optimization in different stages of the TCSC. The selected studies have followed different research methods such as mathematical modeling, simulation, survey, experiment, and case study to achieve their respective objectives.

The difficulty of performance measurement in TCSC was that a wide diversity of metrics has been used to measure performance even for similar products and stages of the suppl chain. Our review also witnessed that several metrics of performance for different products and stages of supply used in the selected studies that showed there is lack of stability on the metrics of performance measurement. The number of performance metrics used in the selected publication are divers and many. Thus, industry leaders and practitioners in the TCSC lacks a framework of performance measurement metrics that enables them to measure the performance of their TCSC.

Conceptual Framework

In this section, we develop a conceptual framework that encompasses all the assertions verified in the systematic review of the literature that provide directions for further investigation. The conceptual model tries to filter out performance metrics in TCSCs.

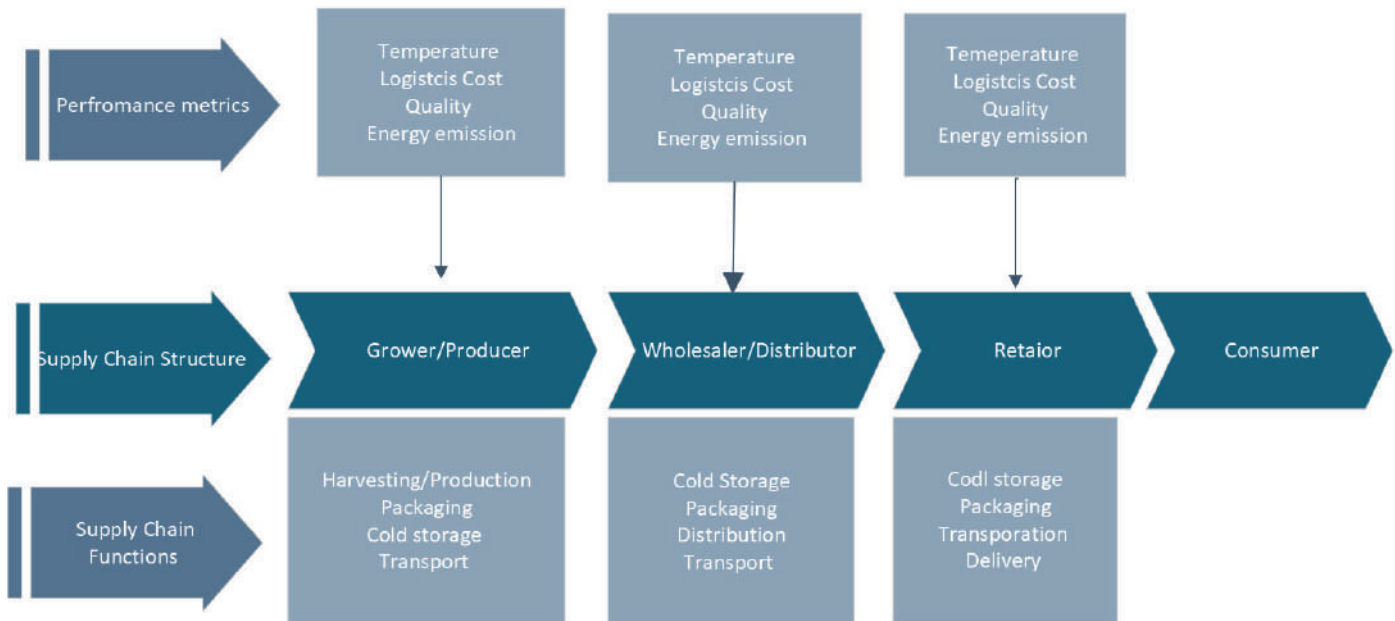


Figure 5 Conceptual Framework

Literature Gap

Our review on the research context of level of income of countries also showed that no paper has been conducted in low-income countries. This evidence revealed that there is a literature gap in the field of TCSC performance measurement that take into consideration low-income countries. The emergence of the concept of Artificial Intelligence is changing the conventional functions of business and supply chain will not an exception. Thus, examining how the emergence of AI affect the existing performance measurement system in TCSC can be a further research area.

Research and Practical Impact

This paper is helpful for managers and industry leaders to know the current progress and possible future developments in the measurement metrics and methods of TCSCs. The findings obtained from this paper will allow practitioners to utilize the best metrics and methods to measure the performance of a TCSC.

The paper portrays insights on the development of metrics and methods of measuring temperature-controlled supply chains and to know the current trends, industry-wide applications, and future research opportunities on performance measurement of temperature-controlled supply chains.

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REDESIGNING LAST-MILE LOGISTICS CONSIDERING CONSUMERS' BEHAVIOUR: A REVIEW OF LITERATURE

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1. Introduction

Last-mile logistics faces significant challenges due to ongoing industry developments, including the surge in e-commerce demand, sustainability concerns, and high operational costs (Boysen et al., 2021). The current trend of digital consumption, accelerated by the COVID-19 pandemic, has made e-commerce and online food delivery the primary means of purchasing necessities, resulting in a notable increase in home deliveries. Consequently, the pressure to achieve decarbonization and zero-emission vehicles in the next two decades adds further complexity to these challenges.

Being in direct contact with consumers, last-mile logistics plays a vital role in satisfying customer needs (Li et al., 2021). However, providing a high level of service can also lead to increased costs and environmental impacts, particularly in urban areas with dense e-customer populations (Hagen and Scheel-Kopeinig, 2021). The rise in home deliveries contributes to traffic congestion and fossil fuel consumption, exacerbating negative impacts on social and environmental well-being (Vasiutina et al., 2021). Additionally, logistics service providers (LSPs) must contend with rising operational costs, driven by customers' expectations of fast and affordable deliveries (Taha and Kyamakya, 2022). Balancing high-quality service and adopting greener practices, such as using electric vehicles, further increases operational costs for LSPs.

Many innovations have been introduced to overcome the challenges within last-mile logistics and many studies have tried to explore them. Past studies have explored the use of new modes of transport in last-mile logistics such as electric tricycles (Xu et al., 2022); cargo bikes and electric van Utomo et al. (2021); and drone delivery (Merkert et al., 2022, Shavarani et al., 2018) while other studies explore the use of new storage modes such as automated (Rabe et al., 2021) and movable parcel lockers.

Numerous studies explored consumer responses to innovations in last-mile logistics, such as collection and delivery points (CDP) (Otter et al., 2017), central last-mile micro depots (Hagen and Scheel-Kopeinig, 2021), parcel locker (Iannaccone et al., 2021) or self-service express cabinets (Jiang et al., 2020) usage in last-mile logistics. Later studies also explored consumers responses on the use of drone delivery both for parcel (Merkert et al., 2022) and food delivery (Waris et al., 2022). Another study investigated how autonomous vehicle for parcel delivery would affect the number of customers and their satisfaction (Shbool et al., 2022). Nevertheless, how last-mile logistics providers should design services considering consumer responses remains an underexplored topic.

Previous studies primarily focused on optimizing last-mile logistics operations from the perspective of logistics service providers (LSPs), with limited consideration of consumer reactions. They addressed topics like revenue maximization (Lin et al., 2022a) or the sustainability and cost impact (Li et al., 2020). Some studies investigated the optimisation of locations and service areas for new service such as smart parcel lockers (Che et al., 2022). Another study explored vehicle routing problems in last-mile logistics by considering self-driving robot (Chen et al., 2021) or considering customer's time satisfaction (Zhang et al., 2020).

Despite these contributions, there is a lack of research directly accounting for consumers' acceptance of new innovations when redesigning a last-mile delivery system. Considering that these innovations aim to meet consumer demand and achieve decarbonization, consumer responses should be considered when planning their operational implementation, influencing the operators' decarbonization pathway. Matching customers' needs with suitable delivery modes remains an essential area for future research, as highlighted by Boysen et al. (2021).

It is quite apparent that understanding last-mile logistics consumers' perception is one of the key points, especially for last mile logistics providers, in designing a robust solution strategy to decarbonise last-mile delivery while fulfilling the consumers' demand.

The main aim of this paper would be to comprehensively analyse the existing body of literature concerning the role and impact of consumers in the last mile logistics process. The primary objective of this study is to identify the research gap within the context of last mile logistics, specifically related to the role of consumers in the light of new innovations in last mile logistics utilising quantitative methodological approach.

2. Methodology

This section discusses the literature review processes to identify the research gap of consumers in last mile logistics services. The process employs the PRISMA 2020 Statement that becoming more popular in operational research such as the study by Utomo et al. (2018). The process started by identifying previous studies via academic journal databases using keywords relevant to the study as the search queries. The collected records were then managed and processed using EndNote 20 software to acquire relevant articles to the topic of the study. The records were then sought for full text retrieval and the unretrieved titles were excluded from the list. The remaining articles in the records were then screened manually to exclude any irrelevant articles resulted in the final records used for this study. The steps carried out is presented in figure 1.

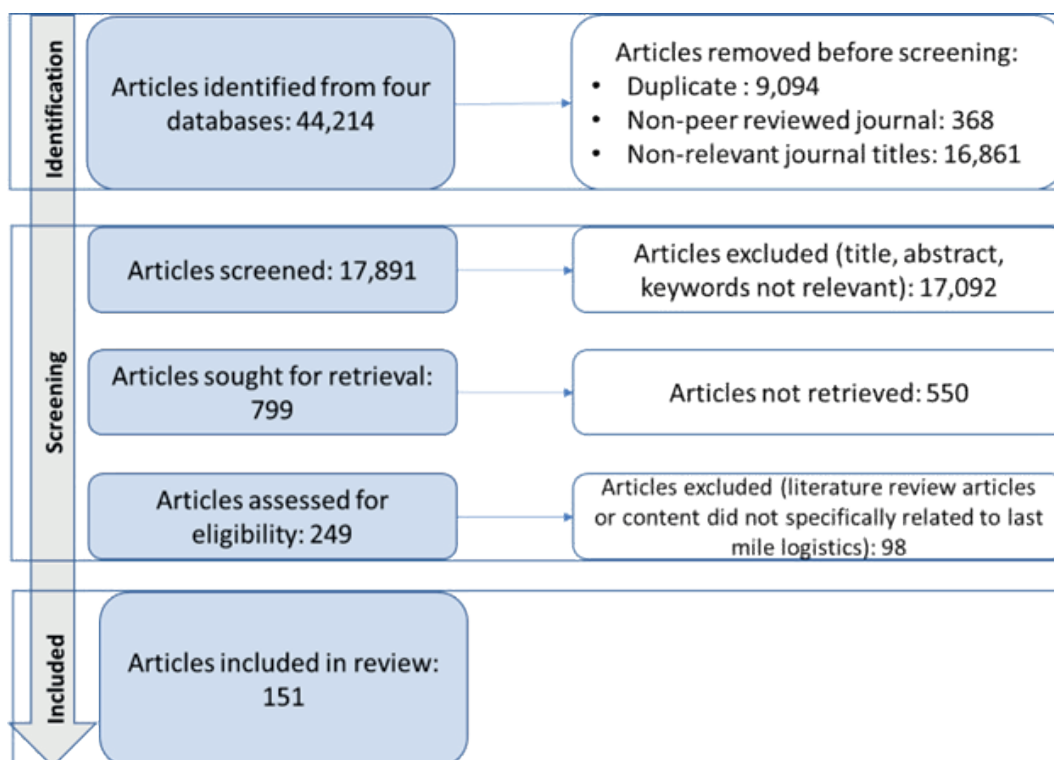


Figure 1 Literature review flow diagram

The literature search was conducted in October 2022 using Proquest, Science Direct, Web of Science and Ebsco databases. The keywords used in the literature search were derived from the main topic of the study that was broken down into four main components which are: (1) last-mile logistics; (2) consumer; (3) decision rules; and (4) quantitative analysis. The synonym or other highly relevant common terms were also included in the search query when retrieving the records from all the databases chosen. The final keywords and the Boolean logic used in the literature search process are as follow:

1. (Last-mile logistics OR last-mile delivery OR urban delivery OR city logistics) AND
2. (Consumer OR customer OR user) AND
3. (Preference OR behaviour OR behavior OR satisfaction OR decision making OR decision rule) AND
4. (Quantitative OR operational research OR simulation modelling OR data analytics OR statistics)

The initial literature search yielded 44,214 records. After removing duplicates and articles from non-peer-reviewed journals or beyond the study's scope, 17,891 articles remained for further screening. The screening process involved filtering based on title, abstract, and keywords, resulting in 799 articles. Out of these, 249 full-text articles were obtained. These full-text articles were assessed for eligibility, and finally, 151 articles were included in the review.

3. Literature analysis and classification

3.1. Literature classification based on stakeholders

Out of the 151 articles analysed, 93 papers (62%) focused on logistics service providers (88 papers discussed third-party logistics providers (3PL) (e.g., Kahr, 2022) and 5 papers discussed non-third-party logistics providers, such as supermarkets or grocery shops (e.g., Truden et al., 2022), 40 papers (26%) on consumers or customers of last-mile logistics (2.5% of which act as sender, such as online retailers that hire 3PL services to deliver products to customers e.g., Brotcorne et al., 2019. And 97.5% act as receiver, such as households who order food through online delivery platforms e.g., Dsouza and Sharma, 2021). The remaining papers (11%) adopted a broader perspective, considering multiple stakeholders like public authorities, local governments, and residents (e.g., Szmelter-Jarosz and Rześny-Cieplińska, 2020). Research on last mile logistics in the sample showed a rising trend in the past five years. Both consumer-focused and logistics service provider-focused papers exhibited a similar increasing pattern.

3.2. Research aims and theoretical lens

The aims of the retained research articles can be classified into several categories (please note that a study can be classified into more than one category) namely:

- 1) Optimisation of last mile logistics service (53 papers e.g., Lin et al., 2022), such as facility location planning and vehicle routing. 50 papers adopted LSP perspective, 2 papers adopted consumers' perspective and one paper combined public administrators and service providers.
- 2) Comparing and evaluating different last mile delivery system (40 papers e.g., Arnold et al., 2018).
- 3) Proposing framework or conceptual design for innovative last mile logistics, such as urban freight consolidation centre (26 papers e.g., Kocsis et al., 2022).
- 4) Consumers preferences and perceptions toward innovative last mile logistics services, such as drone (35 papers e.g., Merkert et al., 2022).

Next, the retained papers are classified based on their theoretical lenses. One finding that could be highlighted is that studies that use LSP perspective mainly employed optimisation theories with very few references to behavioural or social theories e.g., Schnieder et al. (2021). There are 36 papers specifically mention their contribution to theory development (such as theory of planned behaviour, UTAUT and game theory) e.g., Kapser et al. (2021), of which 32 papers took the consumers' perspective and four papers studied the perspective from multiple stakeholders e.g., Kapser et al. (2021)

3.3. Research methodology and type of analysis used in the previous studies

The database search primarily yielded literature employing quantitative methodologies, with only nine research papers deviating from this trend (six used qualitative methodologies, and three adopted mixed methodologies).

There are different analysis techniques used in previous quantitative studies. As much as 49 studies used mathematical modelling such as linear programming e.g., Kahr (2022). The second most common method is statistical modelling with 42 articles in total e.g., Lin et al. (2022b). 10 papers used simulation modelling such as agent-based modelling and simulation (6 papers) e.g., Shbool et al. (2022), system dynamic (2 papers) e.g., Rabe et al. (2021), dynamic traffic simulation (1 paper) e.g., Simoni et al. (2020), and discrete event simulation (1 paper) e.g., Greasley and Assi (2012). The rest used other analysis methods such as multi criteria decision making techniques and game theory e.g., Simić et al. (2021). From the studies that used qualitative methodology, different analysis techniques were used such as critical analysis (1 paper) e.g., Sułkowski et al.

(2022), thematic analysis (2 papers) e.g., Alharbi et al. (2022), and case study (2 papers) e.g., Rosenberg et al. (2021). The studies employing mixed methodologies include studies using SWOT analysis, sustainability balance scorecard, and AHP to identify the sustainable best practice for last mile delivery companies e.g., de Assis et al. (2022).

3.4. The type of freight being transported

Last mile logistics deals with different types of freight. From the literature retained, 122 articles discussed parcel delivery with 77 articles adopted LSP's perspective e.g., Sárdi and Bóna (2021), and 30 articles were focused on consumers' perspective e.g., Merkert et al. (2022). 12 papers discussed food delivery e.g., Dsouza and Sharma (2021) and eight papers discussed grocery delivery e.g., Gatta et al. (2021). From those discussing food delivery, seven focused on consumers intention and acceptance towards food delivery service, while the remaining five papers focused on the LSP's perspective in optimising their food delivery services with one of them also accounted consumer satisfaction in the optimisation e.g., Zhang et al. (2020). From the eight papers that studied grocery delivery service, only three papers focused on the consumers perspective e.g., Gatta et al. (2021) while the other five focused on the LSP e.g., Truden et al. (2022). There is one paper that used both parcel and grocery in the discussion (Serrano-Hernandez et al., 2021) and one paper discussed about postal service (Rostasova et al., 2020) while nine papers did not clearly mention the freight type in their research.

3.5. Logistics service innovation discussed in previous studies: transport modes and storage modes

Innovations introduced in last mile logistics services mainly come in two forms: transport modes used for moving the freight and storing modes after the delivery process finished. For simplicity, this study classifies them as transport modes and storage modes.

Sixty-six of the retained articles discuss innovative transportation modes with drone being the most popular (21 papers) e.g., Li et al. (2020). 20 articles included the use of bicycle, e-bike or e-tricycle e.g., Hagen and Scheel-Kopeinig (2021). Electric vehicles (EV) and autonomous vehicles (AV) with both have ten articles that included them as the transport modes in the studies e.g., Kocsis et al. (2022). There were also several studies that combine and compare new innovations with the traditional modes of transport in last mile delivery system such as vans and cargo bike e.g., Arnold et al. (2018).

There were only small numbers of other transportation modes innovation discussed in the rest of retained papers. Three papers included the use of public transport in last mile logistics while each Unmanned Ground Vehicle (UGV) (Wu et al., 2021) and e-micromobility (Castiglione et al., 2022) only discussed in one paper. There were 66 articles that did not clearly mentioned the modes of transport being studied. Summary of the different transportation modes innovation in the previous studies is provided in figure 3.

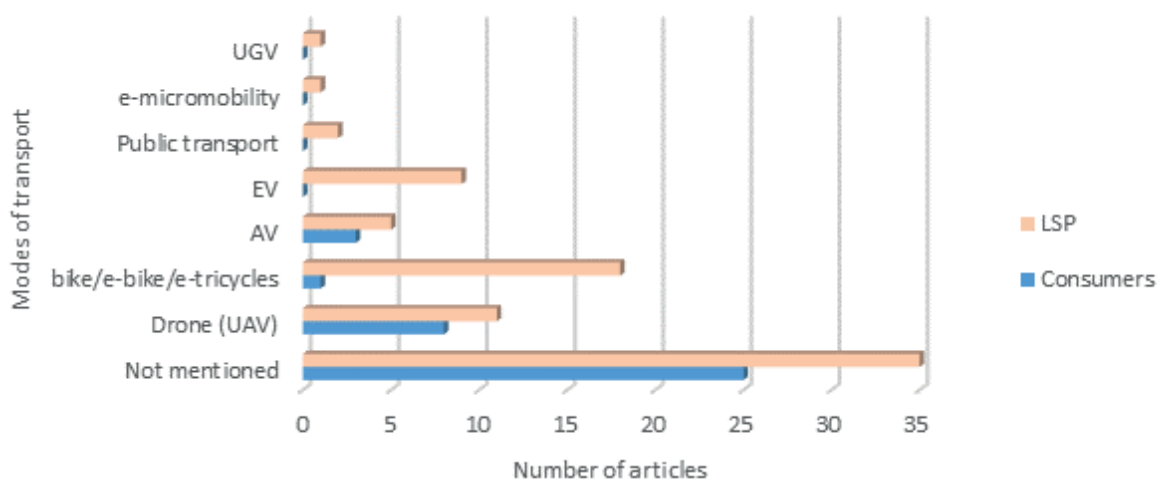


Figure 3 Innovation in modes of transport discussed in the articles

There are four innovative storage modes discussed in the previous paper. First, 22 paper discussed the use of lockers with relevant improvements e.g., Rabe et al. (2021). 18 previous papers discuss the use of micro depot e.g., Rosenberg et al. (2021). Mobile depot is an innovative storage mode which is included in seven research papers e.g., Krstić et al. (2021). Lastly, three articles considered the use of collect and delivery point (CDP) in the last mile logistics studies e.g., Kedia et al. (2019). The remaining 68 papers did not clearly mention the storage mode included in their studies. Figure 4 shows the comparison of the different innovation in storage modes between articles that focused on consumers and LSP.



Figure 4 Innovation in storage modes discussed in the articles

4. Research gaps identified from the literature review

The literature review reveals that the consumers' perspective in last mile logistics remains underexplored. Previous research rarely considers consumers' responses or acceptance towards new innovations when redesigning the last mile delivery system. This limitation indicates that consumers' voices are not adequately heard in the process, leading to potential mismatches between design and consumers' demographical and geographical contexts. However, this presents an opportunity to explore the design of last mile delivery systems that consider consumers' responses and acceptance, aligning with previous studies' calls for investigating new concepts in last mile delivery for appropriate customer segmentation and understanding how delivery attributes may affect different consumers' demographics.

Regarding research methodology and analysis techniques, simulation modelling like agent-based modelling is rarely utilised in last mile logistics research. However, agent-based modelling suits analysing last mile logistics consumers due to its emphasis on decision-makers' behaviour and communication within the system, considering how the system reacts to parameter changes resulting from interactions between decision-makers. Supplementing simulation modelling with statistical analysis can provide a more robust representation of consumers' behaviour. Moreover, exploring other freight types, like groceries and food, alongside parcels, is necessary due to the increasing popularity of online food and grocery delivery services offered by various supermarkets. Additionally, understanding consumers' perceptions of implemented innovations, such as electric vehicles, compared to or combined with more conceptual innovations like drones or community refrigeration in last mile delivery system design, is crucial. For this purpose, studies such as Utomo et al. (2021) can be used as a foundation.

5. Conclusion

In conclusion, the literature review indicates that the perspective of last mile logistics consumers is an underexplored area, with limited attention given to their responses and acceptance of new innovations in the delivery system. The current lack of consideration for consumers' voices in redesigning last mile logistics poses risks of misalignment with their needs and contexts. However, this gap also presents an opportunity for future research to explore how consumer responses can influence the design of sustainable last mile logistics services, especially concerning emerging innovations. Integrating simulation modelling and statistical analysis could offer deeper insights into consumer behaviour and interactions within the system. Moreover, the research should not solely focus on parcel delivery but also explore other freight types, like groceries and food, while examining consumer perceptions of existing innovations like electric vehicles alongside conceptual innovations like drones. By addressing these aspects, researchers can contribute to more consumer-centric and efficient last mile logistics systems that meet evolving needs and promote sustainability.

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ASSESSING ANXIETY AND DEPRESSION AMONG MALAYSIAN SEAFARERS POST-PANDEMIC: A MULTI-CRITERIA DECISION-MAKING APPROACH

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1. Introduction

Seafarers, particularly those employed in the maritime sector, constitute a crucial element within the shipping and maritime domain, both at the local, national, and international levels. Maritime professionals who work at sea are exposed to a range of occupational stressors, which can contribute to the development of mental health issues (Oldenburg et al., 2010; Sampson & Ellis, 2021). Since 2000s, there has been an increased focus within the industry and research community on the mental health and well-being of seafarers consistently reported higher rates of depression, anxiety, and suicidal ideation than general population (Tang et al., 2022). The outbreak of the COVID-19 pandemic in 2020 caused a massive catastrophe that put enormous pressure on individuals, including seafarers. The mental health difficulties seafarers encounter have been notably worsened by the COVID-19 pandemic, mainly attributable to the extensive limitations on travel imposed by many countries (Ranaei et al., 2020).

According to the International Transport Workers Federation (2020), the implementation of control measures and travel restrictions has resulted in approximately 300,000 seafarers being stranded at sea, resulting in a crew change crisis. Seafarers are vital in maintaining global trade and have been essential in operating during the pandemic. They face unique challenges as they navigate pandemic-related restrictions and adjust to evolving lifestyles. Even more, they experience heightened isolation compared to the on-shore professionals due to their remote work environment at sea (Brooks & Greenberg, 2022). In addition, Baygi et al. (2022) highlighted that individuals working as seafarers may face an elevated likelihood of experiencing mental health issues.

Therefore, to address seafarers' mental health challenges, it is essential to prioritise the causes of depression and anxiety and select the most suitable approach to improve their mental health. This study aims to assess the influence of operational, emotional, financial, and health factors on anxiety and depression among seafarers. Two multi-criteria decision-making approaches are utilised: the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS).

2. Literature Review

2.1. Operational Factor

Operational factors pertain to the aspects of a mariner's occupation that may potentially contribute to the development of anxiety and depression. A crucial determinant was the extended duration of labour hours enforced on them due to limitations on crew rotations (Oldenburg et al., 2010). The absence of any respite for seafarers necessitated them to work additional hours, thereby augmenting their tendency to depression. Research has indicated that prolonged working hours adversely impact mental well-being, such as increased stress levels, depression, and even suicidal tendencies (Sliškovi, 2020). A positive correlation was observed between the duration of onboard stay and an increased likelihood of experiencing depression. Seafarers' rigorous workloads might harm their physical and emotional health (Lim et al., 2018). Such situation was also evidenced by a study conducted by Othman et al. (2015), where it noted that the elements of working conditions such as the arrangement of working hours, period of rests and working places can have effect on Malaysian seafarers' psychological conditions. Since the work of seafarers are mainly to ensure safe navigation and operations by monitoring the ship's system and making decision, the unbalanced working hours and workloads may affect their judgement, cognition, and attentiveness when they are working (Ma et al., 2020). In addition, the lack of medical resources intensified their psychological distress (Stannard et al., 2015). The limited access to healthcare services, the inadequate medical

qualifications of ship officers and insufficient medical equipment and supplies onboard resulted in delayed and inadequate treatment options for sailors who fell ill or sustained injuries (Li et al., 2022; Sampson & Ellis, 2021).

2.2. Emotional Factor

Emotional factors apply to the psychological and emotional dimensions inherent in seafaring, which may impact one's mental wellness. Family distancing emerged as a notable factor (Gander et al., 2008). Seafarers frequently encountered prolonged periods of separation from their families and encountered restricted communication channels as a result of inadequate connectivity while at sea (Othman et al., 2015; Zhang & Zhao, 2017). The sailors' experience of isolation was worsened by the presence of multicultural crews and a lack of commonalities with their colleagues, which intensified their longing for their families and increased their depressive symptoms. Furthermore, the lack of support intensified their psychological condition (Devereux & Wadsworth, 2022; Thomas et al., 2003). The limitations imposed on crew changes have resulted in seafarers being confined on board vessels without the customary external assistance they would typically receive from their families. The provision of social support or supportive culture, resulting from both internal and external sources, played a pivotal role in mitigating stress levels. Without proper supports, the motivations of the seafarers will be easily affected especially during critical condition like Covid-19 pandemic (Othman et al., 2015). In addition, the fear of infection such as Covid-19 virus constitute to their feelings of depression (Slišković, 2020). The persistent fear of being infected, adhering to safety measures, and the unpredictability of contracting the virus have amplified psychological distress and compromised their holistic welfare (Li et al., 2022). The depression experienced by seafarers during the pandemic can be attributed to various emotional factors, such as family distancing, lack of support, and fear of infection.

2.3. Financial Factor

The financial factors that relate to the economic aspects of seafarer's life have the potential to exert an influence on their mental health. These factors include a higher cost of living, insufficient emergency funds, and financial issues within their families. One factor was the increased cost of living from the impact of financial crisis and pandemic (Tang, 2022), which became a burden as personnel changes were limited. For instance, seafarers ashore, unable to work due to limited transportation means which result loss source of income, struggled to cover essential expenses (Li et al., 2022), causing anxiety. In addition, the lack of emergency funds added to their financial hardship (Fernandez & Krootjes, 2007). Furthermore, seafarers who lost their employment or had their contracts expire faced family financial difficulties, as their income was the primary source of family support (Slišković, 2020). As such, Guan et al. (2022) suggested that financial stress can cause an economic determinant of depression.

2.4. Health Factor

The health factors relevant to seafarers refer to the different health obstacles they encounter, which may affect their psychological condition. Several health factors have been identified as contributing to this phenomenon, including sleep quality, health status, and health-related behaviour. Inadequate sleep duration and restless sleep, commonly referred to as poor sleep quality, have been found to heighten the likelihood of severe depression among seafarers (Åkerstedt et al., 2004; Jepsen et al., 2015). Such factors are usually associated with the living conditions onboard the ships (Othman et al., 2017), and maintaining a favourable health state can be a protective measure against depression. Health status is measured by morbidity, deterioration, anthropological measurements, mortality, functional status, and quality of life. It includes physical and mental health, claims experience, health care acceptance, medical history, genetic information, insurability, and handicap. Seafarers' health may affect by depression during Covid-19, as studied by Baygi et al. (2022) found that health status is a factor in Covid-19-related depression among sailors. Health-related behaviours of seafarers such as smoking and alcohol consumption are some of the 'harmful' behaviour and lifestyle (Fisk, 2017), significantly contribute to depression among seafarers. This is due to the increased vulnerability of maritime workers with such risky behaviours when they cannot access their usual supplies.

3. Methodology

The study utilised the AHP and the TOPSIS to evaluate and rank the factors influencing anxiety and depression among seafarers. AHP was utilised to structure the decision-making procedure and establish the criteria and sub-criteria hierarchy. Figure 1 shows this study's four-level hierarchical model. The study's main goal is to assess mariners' anxiety and depression.

The second level covers the primary causes of anxiety and depression in seafarers, while the third covers the subfactors. Finally, the fourth level discusses ways to reduce anxiety and despair in this profession. Experts and stakeholders assigned numerical weights to each criterion based on their relative importance by using pairwise comparisons. The AHP results were then used as input for the TOPSIS method (Md Hanafiah et al., 2022), allowing for ranking and selecting the most efficient strategies to improve seafarers' mental health. TOPSIS utilised the concept of close to the optimal solution to evaluate and rank the alternatives according to their performance against the specified criteria (Othman et al., 2015). This approach provided a systematic and robust framework for evaluating the factors of anxiety and depression among seafarers and identifying the optimal strategies for improving their mental health by combining the strengths of AHP and TOPSIS.

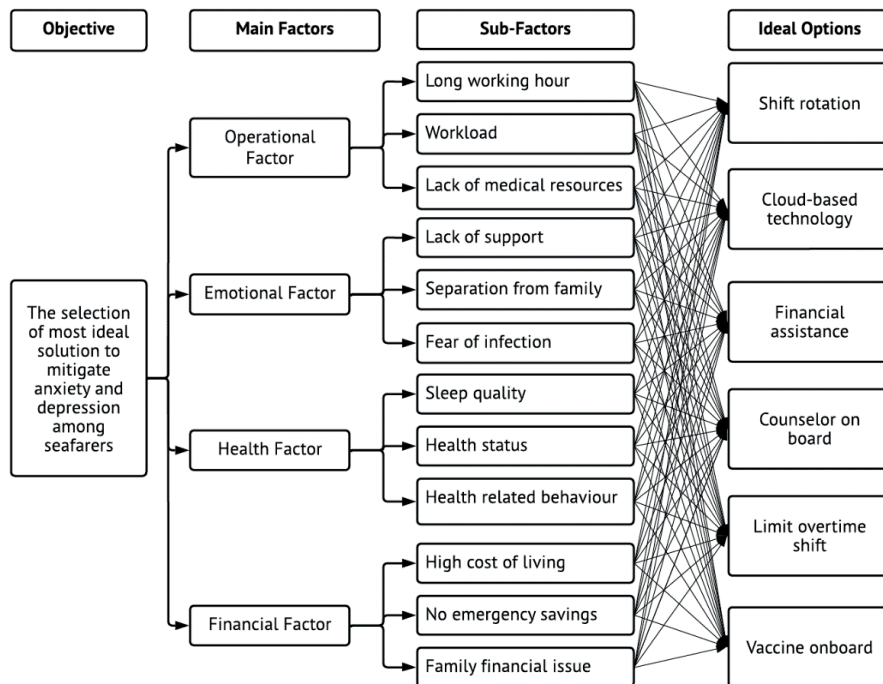


Figure 1: The four-level hierarchy prioritisation of improving seafarers' anxiety and depression approach

4. Empirical Study for the Selection of Most Ideal Approach to Mitigate Anxiety and Depression among Malaysian Seafarers

This study employed AHP and TOPSIS methodologies to collect and analyse empirical data concerning the causes of anxiety and depression among seafarers. By incorporating experts' opinions, the analysis sought to determine the most effective approach for mitigating seafarers' mental health issues, in line with the seafarers' welfare organisations' initiatives to improve seafarers' well-being. The AHP analysis thoroughly compared multiple factors, including operational, emotional, health, and financial aspects. In contrast, the TOPSIS analysis enabled the ranking of the optimal solutions for enhancing seafarers' mental health in relation to anxiety and depression. The study results are discussed to provide decision-makers with insights that will assist them in their efforts to support seafarers' mental health and well-being while on board.

4.1. The main factors contributing to anxiety and depression among Malaysian seafarers during the Covid-19 Pandemic

The AHP results ranked the top three main sub-factors contributing to anxiety and depression among Malaysian seafarers during the Covid-19 pandemic are high cost of living, no emergency savings and separation from family.

Seafarers are currently experiencing increased apprehension regarding their financial security and capacity to fulfil their fundamental necessities due to the shutdown of various industries and restricted sources of income. The increasing daily living expenses contribute to their concerns as they endeavour to achieve financial stability amidst these difficult circumstances. The financial burden of managing the higher expenses and the fear of being unable to obtain fundamental necessities may cause a persistent state of anxiety among seafarers. In addition, the financial strain caused by the high

cost of living may limit their ability to participate in leisure activities or pursue personal aspirations, further contributing to frustration and tension. The overall effect of the Covid-19 pandemic on seafarers has been amplifying their anxiety, particularly with the difficulties posed by the rising cost of living.

The inadequacy of emergency funds has been recognised as a significant element contributing to anxiety and depression among seafarers in Malaysia. Insufficient savings can render seafarers susceptible to unanticipated financial crises, resulting in their anxiety and stress levels. The COVID-19 pandemic has driven up financial concerns among seafarers due to the ambiguity surrounding employment and income stability. This has contributed to their psychological distress, potentially resulting in symptoms of depression. The lack of a financial buffer in contingency funds can render maritime workers feel reliant and devastated when confronted with unforeseen expenditures or decreased earnings. Insufficient emergency savings have been found to have a notable impact on the psychological welfare of seafarers, resulting in increased levels of anxiety and depression amidst the difficult circumstances presented by the Covid-19 pandemic.

The Covid-19 pandemic has resulted in an important sub-factor contributing to depression and anxiety among seafarers in the local area. Specifically, the extended periods spent at sea with limited communication with family and friends have emerged as a significant factor. Moreover, various factors such as family responsibilities, worries regarding the well-being of kin, and difficulties in obtaining shore leave are the downsides of being separated from family. This factor underscores the psychological impact endured by mariners and its role in their challenges with mental well-being.

Of the four main factors evaluated, the operational factor was deemed less significant, suggesting a comparatively lower influence on the prevalence of depression and anxiety among seafarers in the local region in the aftermath of the pandemic.

4.2. Most Ideal Approach to Improve Seafarers' Mental Illness with Anxiety and Depression

Followed by the TOPSIS analysis suggests the three most optimum approaches improve seafarers' mental health, which is the use of cloud-based technology, shift rotation and limiting overtime shift.

The utilisation of cloud-based technology has surfaced as a beneficial instrument for the surveillance and administration of the psychological well-being of seafarers. This technology provides a conceptual framework for proactively addressing psychiatric concerns such as depression and anxiety through predictive analytics and artificial intelligence. The system provides support for clinical care, allows for the evaluation of mental health concerns, offers self-assessment tools online, and promotes communication among members of the naval community. Cloud-based technology is significant in identifying and addressing the mental health needs of seafarers in enclosed environments such as ships, where psychological imbalances may arise. In addition, the use of coping mechanisms can aid both carers and individuals affected with psychological disorders in managing the emotional effects of fear and financial strain. In general, cloud-based technology represents a viable solution for addressing depression among seafarers from Malaysia, as it facilitates streamlined monitoring and intervention processes in the face of the difficult conditions brought about by the Covid-19 pandemic.

The implementation of shift rotation has been suggested as a potential strategy to mitigate the risk of depression and anxiety among Malaysian seafarers. Before the onset of the pandemic, seafarers had the opportunity to undergo crew changes, which enabled them to obtain sufficient rest. However, due to the limitations imposed on crew changes amidst the ongoing pandemic, seafarers are compelled to persist in their duties without adequate repose, increasing their susceptibility to depression. The implementation of shift rotation has been found to be an effective strategy for sailors to work on the ship for a designated duration, followed by adequate rest, thereby mitigating the likelihood of depression. This alternative aims to prioritise sufficient rest for seafarers and reduce the adverse effects of uninterrupted work in the face of the difficult circumstances presented by the pandemic.

A suggestion to restrict overtime shifts is being put forth to improve seafarers' mental health. The practice of working beyond regular hours, commonly known as overtime work, is often pursued by seafarers to increase their earnings. However, it has been observed that this practice may have a detrimental effect on the mental well-being of seafarers. The implementation of a limit on overtime work allows seafarers to acquire sufficient rest during their time on the vessel. Adequate rest is paramount, as inadequate sleep can result in depressive symptoms and fatigue, reducing workers' efficiency and productivity at work. Therefore, implementing restrictions on overtime shifts seeks to mitigate the potential for depression and anxiety among seafarers.

5. Conclusion, implication, and direction for future research

It was commonly recognised that seafarers were subject to a higher probability of experiencing detrimental health outcomes and occupational injuries and fatalities compared to individuals employed in land-based professions. To summarise, the investigation demonstrated that during the Covid-19 pandemic in Malaysia, seafarers' anxiety and depression were influenced by several factors, including the high cost of living, insufficient emergency savings, and family separation. This has explored the potential benefits of addressing these challenges on their work performance, safety, and the overall efficiency of the maritime sector. Thus, the proposed most optimum approach to support the seafaring profession mental health which is important for achieving the sustainable development goals (SDG).

The demographic characteristics of the experts participating in this investigation could impact its outcome. Therefore, additional empirical studies can employ the hierarchy framework in other regions to determine whether comparisons can be made between regions. This limitation suggests that future research can investigate additional factors through expert interviews and enhance the hierarchical framework. In conclusion, the findings of this study can be compared to other methods, including statistical, structural equation, simulation, and deep learning technology.

5.1. Practical and societal impacts

It is recommended that ship owners and crewing companies emphasise conducting routine evaluations of seafarers' mental health, expand the range of well-being to encompass mental health, and foster organisational cultures that encourage psychological safety for seafarers. In addition, it is imperative to allocate additional resources towards onboard facilities that enable and prioritise the provision of mental health care to all crew members operating on vessels by using cloud-based technology.

5.2. Research impacts

The study's outcomes and prospective remedies can significantly contribute to enhancing seafarers' psychological well-being, elevating their quality of life, job satisfaction, and overall well-being.

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INSERTING FREIGHT RAILWAYS INTO VALUE CHAINS IN SOUTHERN AFRICA

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Introduction

Rail freight transport is underperforming in South Africa (RSA) against the backdrop of the significant rail freight growth of its BRICS partners (countries with similar developmental state objectives and related challenges). Rail freight tonne-km doubled in Russia and China over the past two decades, while almost quadrupling in India (refer Figure 1). The state of rail freight in the rest of the modelled Southern Africa (SAF) subset¹ is even more challenged, with RSA contributing 93% of the 132 billion tonne-km. RSA's aggregate data, however, obscures the poor performance of general rail freight (GFB), since the railway's tonne-km is dominated by the export coal and export iron ore lines, which contribute two-thirds to RSA's total.

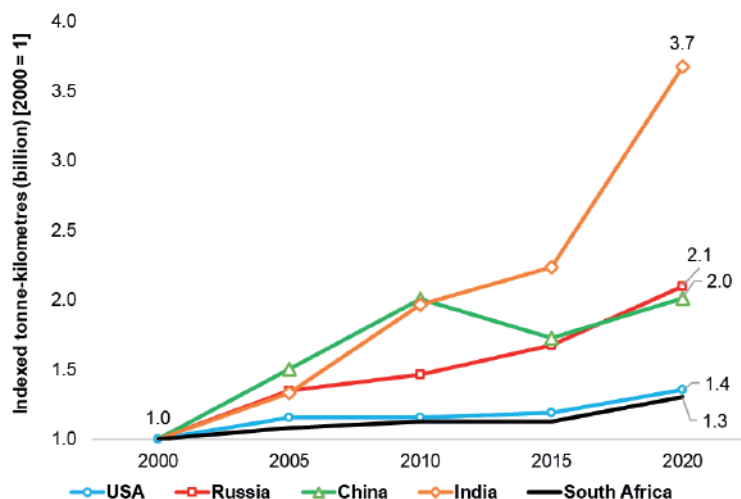


Figure 1: RSA's rail freight activity relative to the significant rail economies (created by authors based on UIC data for 2000 to 2020)

This underperformance is driven by large, unprofitable, narrow gauge rail networks; the underutilisation of rail for suitable freight due to inter alia a failing regulatory environment, low investment levels and poor performance; and is exacerbated by stagnating or declining GDP growth in all major SAF economies over the decade up to 2020 (Edo, Osadolor, & Dading, 2020). As a proxy for rail network size productivity, the SAF subset represents 3.3% of the global rail network's approximate 1.3 million route-km (Salas, 2022), while SAF's gross domestic product (GDP) represents a mere 0.9% of the world's near \$85 trillion GDP. SAF's contribution to global rail route-km is, therefore, almost four times that of its contribution to global GDP. All the SAF countries have a narrow gauge rail network (with 20% of the region's network even below the typical 1 067mm narrow gauge) (Bullock, 2009; World Bank rail route-km data over various years), with only 40% of RSA's rail network electrified (Transnet, 2022) and no electrification in the rest of the subset (International Energy Agency, 2019). However, in RSA, more than 90% of the country's rail freight tonne-km are hauled over electrified routes. A standard gauge rail network and rail electrification can each double carrying capacity (rail potential, however, has to be estimated on a sectorally disaggregated basis with an understanding of specific investments required).

The next sections of the paper expand on the underutilisation of rail and the underperforming regulatory environment. The underutilisation of rail is expounded through aggregate density analysis and how it exhibits itself in market share gaps across

all freight segments, exacerbated by a dearth in rail rolling stock investment. In the case of RSA, the political leadership failures that gave rise to these challenges are well-publicised, but this narrative unfortunately rings true across the sub-continent. This paper closes with immediate imperatives to support the turnaround of the rail freight sector, with specific reference to RSA.

Current issues

Density challenges

One of the core objectives of a railway is densification, which is defined as a major increase in tonne-km per route-kilometre due to its dramatic effect on lowering rail unit fixed cost (given the large fixed cost component of rail) (Harris, 1977; Janic, 2007; World Bank, 2011: 33-35). RSA's export coal and iron ore lines are highly densified due to significant dedicated bulk volumes and short route-km dedicated to these flows (this extreme density is not possible to emulate with general freight, but it provides an indication of possibilities under freight consolidation over a rationalised network). RSA's GFB network and selected SAF countries perform very poorly on this indicator compared to the density achieved by the USA, Canada and India (refer to Table 1).

Country	Rail freight tonne-km (millions)	Rail route-km	Current density (tonne-km/route-km)
RSA total	122 750	20 787	5.9
RSA export coal line	34 693	739	46.9
RSA export iron ore line	48 023	931	51.6
RSA GFB	40 034	19 117	2.1
Selected SAF			
Kenya	1 399	2 236	0.6
Namibia	1 000	2 382	0.4
Tanzania	1 196	2 701	0.4
The Republic of the Congo	1 297	893	1.5
Uganda	218	1 244	0.2
Selected global			
USA	2 357 117	228 218	10.3
Canada	578 632	52 002	11.1
India	738 523	66 030	11.2

Table 1: Rail freight density comparisons for RSA, large SAF railways and selected global railways [created by authors based on GAIN FDM™ (2022) data for tonne-km and rail route-km in RSA; UIC² data for USA, Canada, and India's tonne-km (2019) and route-km (2015); and RAFM data for SAF tonne-km (2022) and route-km (2015)]

This inferior performance is further evidenced in RSA's and SAF's low GDP to rail network ratio of approximately \$16 million and \$19 million per rail route-km respectively, which is dwarfed by the USA's \$92 million, Canada's \$32 million and India's \$40 million per rail route-km (approximate figures based on World Bank GDP data for 2020). The low density is a symptom of two factors: a rail network that is too expansive based on current and future density potential, and a low rail market share of rail-friendly freight.³

Commodity-level segmented rail market share data has only been developed for RSA over the past two decades through the GAIN FDM™, however, the dramatic downturn in RSA's use of general rail since the 1980s is evident from aggregate historic tonne-km data (see Figure 2). Growth in rail freight was mostly only due to the rail-only export coal and export iron ore lines.

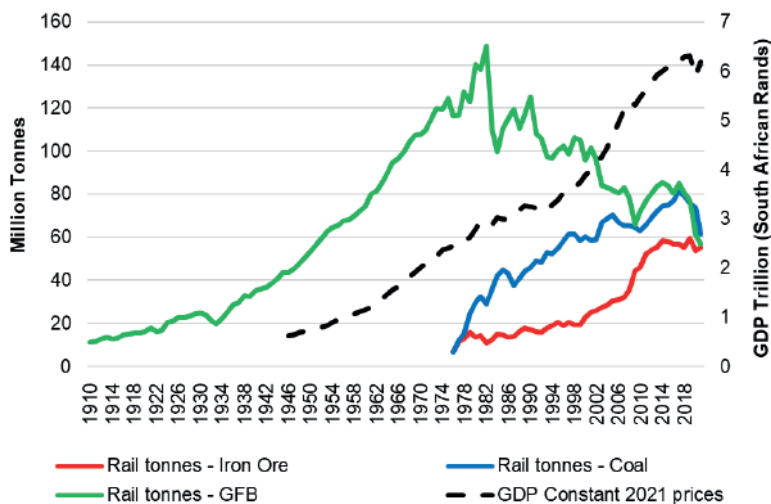


Figure 2: Comparison between RSA's historic rail volumes and GDP (created by authors based on data from the GAIN FDM™, 2022)

RSA: Rail market share challenges⁴

To illustrate the country's rail freight challenges, the market share of the total rail-friendly freight in 2019 was estimated at 181 billion tonne-km, of which only 141 billion tonne-km was transported by rail (this includes the export coal and export iron ore lines). Similarly, the GFB (which excludes those lines) rail-friendly freight market was estimated at 47 billion tonne-km, whereof rail only delivered 18 billion tonne-km in 2019. The gap in rail freight market share that should be on rail is depicted in Figure 3 per freight-flow segment. For RSA, these gaps can be summarised as follows:

- For export mining freight-flows⁵ (which are rail's forte, with almost all freight classified as rail-friendly), only 90% of the country's export mining tonne-km were captured by rail in 2019. This equated to an 8% gap in freight that should have been on rail but was not. This was mainly attributable to challenges in meeting export mining requirements. This gap has been growing steadily over the last decade. For context, in 2020, an 8% gap would represent about 10.1 billion missing tonne-km. This situation is currently worsening with extreme failures that cannot be fully regained by road. A lost 20 million tonnes of, for instance coal in 2022, will only be replaced by five million tonnes on road.
- About two-thirds of domestic mining freight-flows⁶ is rail-friendly, yet only 35% was transported by rail in 2019. The gaps are mostly in the Mpumalanga coal fields and domestic manganese for the steel industry. For 2020, a 28% gap would equate to approximately seven billion tonne-km.
- For semi-beneficiated freight flows⁷, which refer to large industrial flows between beneficiation centres, rail only had 12% of a potential 32% market share in this segment in 2019. Rail service delivery challenges led to a shift to road resulting in the disuse of industrial sidings. Since these sidings are costly to maintain, disuse led to decay. This 20% gap would translate to just over two billion missing tonne-km in 2020.
- Rail's biggest market share gap is related to finished goods (specifically those that are palletised) freight-flows⁸, where rail has only 2% of a potential 30% market share in this segment, basically a non-existent service. This freight complies with all the aspects of rail economics i.e., uniformity, long distances, and density (refer to footnote 3). The failure to develop an intermodal service here is baffling.
- Even for agriculture freight flows⁹, rail can capture almost 10% of the overall tonne-km, yet it only served 3% of this market in 2019. Freight can be consolidated (e.g., at silos) to provide sufficient density for a rail solution, especially when destined for production centres. In 2020, this gap of around 6% would represent about two billion tonne-km.

The biggest undeveloped rail service opportunity is, therefore, in the palletised long-distance freight segment, whilst the biggest gap relative to existing competencies is in domestic minerals.

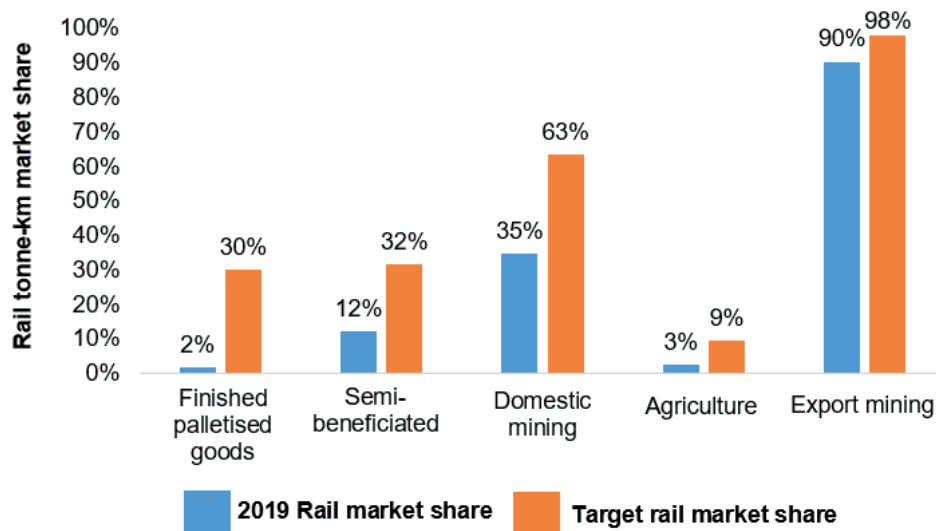


Figure 3: Rail's 2019 and potential tonne-km market share for each segmentation type (created by authors based on 2022 data from the GAIN FDM™)

The weakened role of rail in the economy is also due to the lack of investment. The country's road freight sector invested significantly in road trucks and trailers over the past 15 years (see Figure 4). In stark contrast, there has been a severe lack of rail investment in rolling stock technologies and locomotives with no new locomotives procured between 1994 and 2008, while only little new wagons were acquired. Simultaneously, the government invested significantly in road corridor infrastructure through SANRAL while failing to develop rail corridors (SANRAL, 2022).

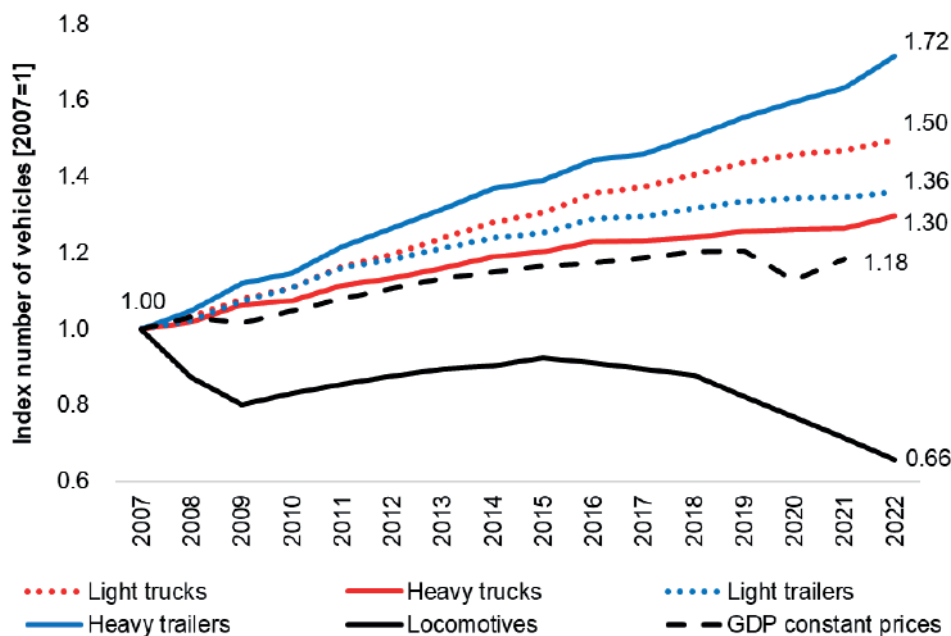


Figure 4: Disparity between RSA's road and rail freight rolling stock investments (created by authors based on eNaTIS vehicle data and World Bank GDP data)

The continuation of these challenges well past the democratisation of RSA's economy can be attributed to the lack of stewardship and the policy reform challenges that have plagued RSA's freight transport sector since deregulation (apart from the narrow gauge decision, but this could have been partly negated by route rationalisation, densification and intermodalism).

Poor stewardship and the absence of rail reform

The main force perpetuating rail freight challenges is the lack of stewardship, which refers to the lack of a leadership culture based on a deep understanding of the strategic vision for and operation of railway assets in the context of macroeconomic trade-offs. This leadership failure in government has unfortunately also led to a societal decline with rampant corruption and vandalism being the order of the day.

The appointment of a full new board and management team at Transnet in 2018 did not result in any significant turnaround, and even the export coal line is expected to deliver 20 million tonnes less in 2022 (27% of the par volume). This is against the backdrop of the continuous failure to implement well-developed policies most notably the Reconstruction and Development Programme (RDP) of 1994, the 1996 White Paper on National Transport Policy and the 1998 Moving South Africa (MSA) strategy. These documents called for ‘all the right things’ for a sustainable railway such as modal shift, integration between modes, comprehensive corridor development, and a drive towards densification of the core network (much of which would have been enabled by the development of intermodal solutions) – none of these were ever implemented. Although some direction has emerged in recent years, policy leadership has mostly been absent with the Department of Transport (DoT) struggling to facilitate meaningful rail reform.

Policy failures were already evident post-deregulation in the 1990s which created an uneven playing field between road and rail. The road freight industry was, and still is, cross-subsidised by passenger cars due to a lack of sufficient user-pay charges for road infrastructure. There were efficiency advantages from large allowed gross vehicle mass – RSA’s maximum is 56 tonnes vs. Europe’s 40 tonnes (European Parliamentary Research Service of the European Parliament, 2011) and the USA’s 36 tonnes (Shuster, 2015) – which were compounded by overloading. At the same time, rail was not able to provide the door-to-door solutions and reliability increasingly being required by a growing manufacturing economy. The loss of freight (and resulting density challenges) was compounded by the rationalisation of motive power and employment in the absence of rail network size (rail route-kilometre) rationalisation, which placed a heavy burden on the rail network’s fixed costs. This has resulted in a rail system which is understaffed for its size but overstaffed for its output. RSA’s growth in tonne-km was only attributable to its ring-fenced coal and iron ore export lines (refer Figure 2).

The many failings of the freight railway have also led to an over-reliance, and consequent strain, on road transport. In addition, many of the country’s port and trade issues are also exacerbated by the deterioration of the freight railway (e.g., congestion due to excessive road transport, and delays on rail).

Increasing tonne-km through market principles in a deregulated environment and rationalising low-density lines will improve density, productivity, and profitability. Table 2 shows how these levers can help RSA to achieve a potential density of 10.8, which is better than the USA’s current density and comparable to Canada and India’s current density performance (refer to Table 1). Applying these principles can also help other countries in SAF to potentially quintuple their current density. In the case of both RSA and SAF this will, however, require dedicated investments; the full business case, therefore, still needs to be developed.

In the next section, key actions are proposed to facilitate this shift.

Country	Current density (tonne-km/route km)	Potential density with network rationalisation (tonne-km/ route km)
RSA total	5.9	
RSA GFB	2.1	
RSA potential GFB density with rail-friendly shift	4.5	
RSA potential GFB density with rail-friendly shift		10.8
Selected SAF countries		
Kenya	0.6	3.1
Namibia	0.4	2.1
Tanzania	0.4	2.2
The Republic of the Congo	1.5	7.3
Uganda	0.2	0.9

Table 2: Potential rail freight density in RSA and SAF

Immediate next steps

The failure to implement any macrologistics policy over the past two decades, combined with the government's catastrophic inaction on corruption, have made the strategic options for Transnet limited. It also means that there is now a greater imperative than ever for privatisation of some components, which is the ruling party's own doing – a decade ago much more of the core components could have stayed in the national fiscus if it were run based on basic stewardship principles. Given the increasing failures over the past couple of years, and the inability of the new management to initiate a turnaround, it has become critical for the President to act decisively and appoint an agent or curator to take charge of rail's turnaround plan. The curator must be accountable for executing the agreed turnaround strategy free from political interference.

The immediate focus of the curator should be operational to save the railway, namely to (1) prioritise and ensure maintenance; (2) safeguard against vandalism, sabotage and theft; (3) prioritise and protect operational systems such as signalling; (4) prioritise and run trains for the most important customers; and (5) zero tolerance for corruption. In terms of the railway's internal functions, this translates into more operational slots. In terms of its relationship with the market, delivery on more filled slots, and in terms of its relationship with the market and broader society, more protected slots.

As a separate activity, the curator must facilitate the privatisation of the coal and iron ore export lines with immediate effect by selling them to the mines, an Richards Bay Coal Terminal-like consortium or another group that represents engineering firms, freight owners and the government.

In parallel with these immediate focus areas, the curator must fast-track the separation process to facilitate the focus, and government and private sector investment, required for rail turnaround. Given the current state of the railway, horizontal separation refers to:

1. Horizontal separation between a low-density and a core, high-density GFB network:
 - a. Solutions for the low-density lines will vary between a concession and abandonment spectrum based on a case-by-case evaluation.
 - b. Densified non-core lines can remain as feeders to the core network, while viable low-density lines could have transition points to the core. Non-viable low-density lines will have to be abandoned or subsidised and links to the core done by road transport.
2. Within the high-density GFB network, horizontal separation between lines (permanent way) and terminals:
 - a. As far as lines are concerned, vertical separation could also be possible, initially through accounting separation of the permanent way (maintenance and line building) and the slot creator (signalling and operations).
 - b. Many rail terminals can easily be funded privately if an open-access regime is instated.
 - c. In the short term, government funding of the core network is required, like that of national roads under SANRAL. In the longer term, this should be transitioned to a self-sufficient high-volume intermodal transport network.
3. Within the core, high-density GFB network, horizontal separation also occurs between motive power and wagons.
 - a. Wagons can easily be funded privately if an open-access regime is instated. Private ownership of locomotives is more complex. In a mature economy a few train 'companies' can own locomotive fleets that provide hook-and-haul services for the wagons. This would mean around 20 to 50 wagon fleet owners and at most, in RSA, 2 to 3 locomotive operators.

The resulting system can be managed and financed separately but work together to achieve a modal shift. These separation options are summarised in Figure 5.

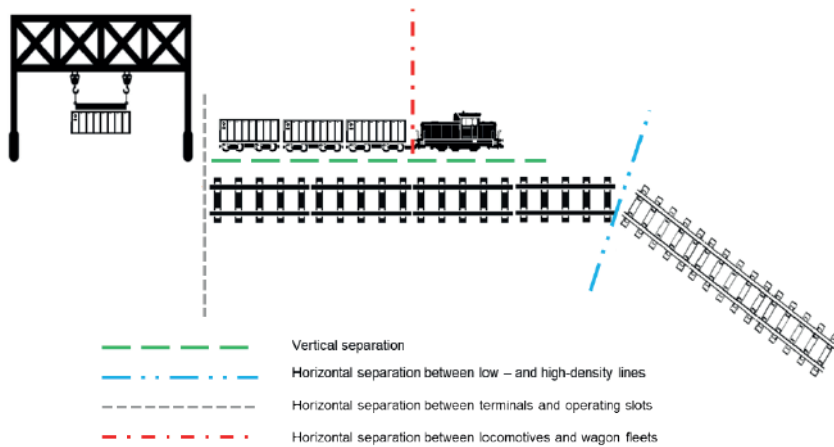


Figure 5: Rail separation options (Havenga, De Bod, Simpson, Swarts & Witthöft, 2021)

The 2022 White Paper on the National Rail Policy allows for inter alia private sector involvement in the railway through open access to the network; highlights that government funding will be required for the rail network; and emphasises that rail economic regulation must be introduced to manage core network access, as well as to regulate road transport to ensure safety and equitable user-pay principles (Department of Transport, 2022). The White Paper, therefore, supports the key requirements of rail turnaround and must now be passed as an Act of Parliament to facilitate the turnaround. The 2022 National Infrastructure Plan, which falls under the Infrastructure Development Act of 2014, details the importance of integration between modes (road, rail and ports), freight villages and terminals (along with the various spheres of government); the development of intermodal solutions (including Special Economic Zones); all enabled through robust planning cycles informed by rigorous macrologistics freight demand modelling (Department of Public Works and Infrastructure, 2022). The policy environment is therefore fitting but requires implementation. This might require the appointment of a strong policy administrator at the DoT.

The private sector needs to call for, or initiate, macrologistics master planning (across modes and value chains) and lobby diligently to ensure the appointment of capable professionals to act as custodians of the railway system to oversee the turnaround strategy. Large freight owners must also be willing to engage financially through driving privatisation of the export coal and iron ore lines, investing in terminals and rolling stock in the short term, and engaging in establishing domestic intermodal solutions and subsequent freight villages in the medium to long term. While the horizontal and vertical separation process is implemented the private sector could aid with train planning, maintenance and security which could be offset by tax breaks.

Successful rail reform in RSA can provide some guidelines to the broader region. This could result in greater bulk transport efficiency and more seamless cross-border movements. Since many countries in the SAF region are landlocked and consequently heavily impacted by the operability of borders, this improvement could speed up intra-regional trade and ensure freight flows are more dependable.

Restructuring current railway assets to increase density and to prioritise critical areas of the region's underlying economies are also expected to increase the overall quality and capacity of linked infrastructure (such as roads, ports, and terminals) due to the unlocking of funds and the increased profitability of value chains. This could further facilitate vital trade flows, especially around food security such as grain imports (although localisation of food supply should also be pursued).

The Department of Public Enterprises, which represents the shareholder of Transnet has recently for the first time appointed a competent temporary deputy director general to manage Transnet and rail oversight. It is assumed that a turnaround strategy and new direction could emerge from this appointment.

¹The modelled SAF subset includes the following countries within Sub-Saharan Africa: Angola, Botswana, Burundi, The Democratic Republic of the Congo, Eswatini, Kenya, Lesotho, Malawi, Mozambique, Namibia, The Republic of the Congo, Rwanda, South Africa (RSA), Tanzania, Uganda, Zambia, and Zimbabwe. Throughout the paper, the rest of SAF, therefore, refers to this subset excluding RSA.

² UIC = French acronym of “Union Internationale des Chemins de fer”, translated as International Union of Railways.

³ In simple terms, rail-friendly freight refers to freight that is uniform (i.e., unitised onto pallets and pallet-friendly containers), over long distances on highly densified routes, with dense origin and destination points.

⁴ This level of market share data is not available for the Southern Africa (SAF) subset. The negligible role of rail in these Southern African (SAF) countries was, however, mentioned in the introductory section of this chapter.

⁵ In RSA, this refers to the bulk exports of coal, iron ore and manganese, while in the SAF subset this refers to crude oil exports in Angola. These flows are characterised by high density, long distances and limited (often single) origins connecting to ports via dedicated rail and pipeline ‘export machines’ respectively. Other general mining exports mean more common-use facilities and sharing of road and rail infrastructure with other value chains. With mining deposits typically in the deep hinterland, these movements often overburden rural facilities.

⁶ Movement of bulk local minerals to domestic beneficiation centres. These flows do not follow typical freight corridors, but rural routes. This freight is, however, rail economical (uniform products, dense flows and large terminals) and places heavy burdens on road infrastructure if transported by road.

⁷ Flows of semi-beneficiated, heavy break-bulk commodities between intermediate and final processing facilities. These flows tend to share infrastructure with other value chains, but because factories are often closer to major cities, corridors begin to develop. Freight movement by road and rail requires dedicated equipment and, for rail, dedicated sidings are often connected. Rail movements are more complicated and require train building for wagonload traffic.

⁸ The flow of FMCG commodities of higher value between manufacturing facilities, distribution centres and retailers. This includes the shipment of final goods to DCs, which are often unitized on pallets and could be containerized, therefore not needing a vast array of specialized equipment. Containers can use rail and large curtain-side interlink trucks on road. Processed foods form a large part of these value chains. It also includes distribution between DCs. These are similar to the aforementioned flows, but with highly concentrated OD’s and mostly on corridors, meaning that it could be rail-friendly.

⁹ The flow of agricultural bulk from rural areas and delivery of consumer goods to these areas. The collection of these commodities is dispersed with a heavy burden on rural infrastructure. It is sometimes unitized at silos or packing centres in which case the further downward value chain is exactly the same as for domestic mining.

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EXPLORING ACTOR ALIGNMENT FOR SUSTAINABLE CITY LOGISTICS SOLUTIONS IN THE CITY INTERNAL ECOSYSTEM – A CASE STUDY OF HELSINKI

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Purpose

There is an increased need for more sustainable city logistics solutions in the increasingly complex city logistics ecosystem. The goal of this study is to explore the alignment structure of the multilateral internal city logistics actors and their joint effort to create more sustainable city logistics solutions, following the ecosystem as a structure concept.

Research Approach

A single case study methodology, exploring the internal ecosystem in the city of Helsinki, was taken. Interviews and secondary data were used, and respondents included city department officials as well as regional development companies and programs running development pilots.

Findings and Originality

Based on the reports and interviews, we observed that in general, Helsinki city has a clear innovation and technology emphasis pertaining to sustainable city logistics. However, at the same time a fragmentation of efforts and a lack of cohesion is present observed in the discrepancy between the importance of the overall goal of carbon neutrality and anchoring sustainable city logistics solutions to it through actions. The heightened emphasis on innovation to reach city logistics sustainability may result in a more passive role for the city.

Research Impact

The research contributes to a better understanding of the role and influence of the internal city actors on sustainable city logistics development. The ecosystem as a structure view provides a better understanding of how internal city actors and their activities are aligned.

Practical Impact

This research offers insights for policy guidelines and can help in guiding development of sustainable city logistics solutions.

Keywords: City logistics, sustainability, innovation, city logistics, internal ecosystem, actors

Introduction

City logistics research examines a complex field where interdependencies among resident well-being, logistics and transport systems, and the administrative decision making and policy measures affecting the sustainability and livability in cities have become increasingly important (Cardenas et al., 2017). Reducing and managing city traffic and freight in cities is of heightened importance due to climate change (Paddeu et al., 2018). As an example, one fifth of carbon emissions in Helsinki come from traffic, and the city of Helsinki has an ambitious target of being climate neutral by 2030 (Helsinki City, 2021). However, the complexity of the city logistics system makes sustainability development challenging for cities, and holistic approaches are needed to address sustainability concerns (Björger et al., 2021). Cities need to cater and balance both resident, business, and other stakeholder needs. This study explores various city actors' activities taking a joint goal perspective. The view on ecosystems as structures, aligning actors in accordance with their goals (Adner, 2017), together with city logistics literature, serves as the basis for this study, where the departments, sub-departments, and task forces

with the goal of creating sustainable city logistics solutions forms its own internal ecosystem of actors. We investigate a single case of Helsinki city actors. Here the joint goal of the city actors is illustrated by the sustainability strategy of the city of Helsinki (City of Helsinki, 2018) and specifically the target of carbon neutrality by 2030 (Helsinki City, 2021). The case study investigates how this overall goal is translated into the context of sustainable city logistics. The goal of the study is to explore the alignment structure of the multilateral internal city logistics actors and their joint effort to create more sustainable city logistics solutions cf. (Adner, 2017).

Literature Review

The city logistics landscape is becoming increasingly complex (Boysen et al., 2021) and complexity is added by the many heterogenous stakeholders involved (Mangano & Zenezini, 2019), including residents, shippers, receivers, logistics service providers (LSPs), and local authorities (Kiba-Janiak, 2016). All these actors have varying expectations and goals (Lindholm & Browne, 2013), that can be hard to find unified views on (Gammelgaard, 2015). The biggest group of city logistics research focuses on commercial and customer perspectives (Kiba-Janiak et al., 2021), so there is need for a wider variety of other viewpoints. Previous research has provided understanding on stakeholders in city logistics including, for example city logistics project implementation involving stakeholders from an organizational change perspective (Gammelgaard, 2015), actor roles and public-private interactions in networks (Lindkvist et al., 2022), and stakeholder reactions to urban freight policy innovation (Stathopoulos et al., 2012). Many studies have focused on a city as one homogenous actor amongst other stakeholders. The role of cities and other local authorities in developing sustainable city logistics solutions is crucial, as they carry the role of improving the quality of life for the inhabitants (Kiba-Janiak, 2016; Kiba-Janiak et al., 2021). But many local authorities struggle with designing incentives and regulation that would support sustainable city logistics (Fontaine et al., 2023), so there is a need to better include city logistics in city planning and development (Kiba-Janiak et al., 2021), and a more strategic approach as well as specific measures are needed in to support high-level goals such as emission reduction (Akgün et al., 2019). City logistics policy can take the form of regulatory measures such as vehicle size and weight restrictions, market-based solutions such as congestions charges, land use and planning measures such as parking spaces, or infrastructure developments including space for urban consolidation centers (Cardenas et al., 2017). In the sustainable city logistics context, innovation becomes relevant as innovation is a primary driver to achieve sustainability in logistics (Roscoe et al., 2016) and policy makers and regulators need to promote both digitalization and innovation, to foster sustainable solutions (Ardito, 2023). Government policies and investments can play a key role in initiating sustainable business models and often a local authority can be the customer of innovative services (Guo et al., 2022).

In the complex city logistics context, it is crucial to understand how cities work to develop sustainable city logistics. Before a city can function as an entity, its internal city logistics processes need to be aligned. As alignment of goals, activities and other measures has been pinpointed by previous research as crucial for city logistics efforts (Akgün et al., 2019; Fontaine et al., 2023; Gammelgaard, 2015; Kiba-Janiak et al., 2021), this study places the joint goal of sustainable city logistics at the core. Thus, the approach of “ecosystem as a structure” defined by Adner, (2017, p. 40) as the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize, is chosen as a theoretical basis for analysis. A city could be described as an ecosystem-as-affiliation, but this study specifically focuses on the interdependencies and alignment of the actors that creates the internal city ecosystem surrounding sustainable city logistics value creation, making the perspective of (Adner, 2017) suitable. Thus, the analysis focuses on the alignment structure of the multilateral internal city logistics actors and their joint effort to create more sustainable city logistics solutions.

Methodology

A single case study approach, that looks at the actors within Helsinki city, was taken to give deep insight in the phenomenon studied (Yin, 2018). The unit of analysis is the organizational units within the city of Helsinki (Finland) and their respective activities towards sustainable city logistics. Interviews and secondary data, such as policy documents and reports, were used. Respondents included city department officials responsible for traffic, environment, and business development as well as regional development companies and programs running last mile and urban development pilots. Respondents were purposefully sampled (Patton, 2002) aided by a snowballing technique (Noy, 2008). Due to the intricacy of city organization, the researchers approached selected city departments and discussed with them to select appropriate respondents. Respondents are presented in table 1. When the interviews were completed, manual pre-coding was used to get an overview of the data, and later structural coding was applied (Saldaña, 2009).

Table 1 Actors and respondents

Code	Actor	Respondent	Roles and Organization
Core01	Mobility Lab (part of testbed Helsinki): an administratively a cooperation between Business Helsinki and Forum Virium, also strongly supported by the Urban Environment Division	CR1	Project Manager at Business Helsinki, Testbed Helsinki
		CR2	Project Manager at Forum Virium Smart Mobility Division
Core02	Urban Environment Division	CR3	Traffic Engineer
Core03	Forum Virium, Helsinki City Development Company	CR4	Project Manager at City Logistics Project division t Forum Virium
Core04	Business Helsinki	CR5	Leading Specialist, Business Helsinki Innovation Services
		CR6	Business Helsinki, Ecosystem Services
Supp01	Helsinki City Climate Unit	SR1	Project Director, Climate unit
Supp02	Urban Tech Incubator for clean and sustainable urban technology	SR2	Program Manager
		SR3	Business Advisor

To triangulate interview findings, secondary data was analyzed and compared to increase validity (Voss et al., 2002). The researchers selected a total of 23 the reports and other secondary data in accordance with relevance for the research topic and with the aid of the respondents.

Results: The Internal Sustainable City Logistics Ecosystem in Helsinki

This section presents the results by taking the “ecosystem as a structure” (Adner, 2017) perspective to show of how internal city actors and their activities are aligned. The multilateral set of actors (cf. Adner 2017) within the city of Helsinki need interact to meet the overall carbon neutrality goal, but also to support sustainable city logistics development. We were able to identify a core group of actors (see table 1) including the Mobility Lab, the Urban Environment Division, Forum Virium (Helsinki City Development Company) and Business Helsinki as well as the supporting actors Helsinki City Climate Unit and the Urban Tech Incubator. Following the goal alignment thought of Adner (2017), this means that the boundaries of the internal city ecosystem are created by the carbon neutrality 2030 goal of the city and the alignment of the actors is structured around their relative influence on the development of sustainable city logistics solutions. City internal collaborative actors were also identified in the interviews, but not included in the current study. This internal ecosystem is illustrated in figure 1.

Outside these boundaries, actors influence the goal, but are not directly aligned with it, as they are city external. For example, actor Core02 and Core04, mentioned the interdependencies both with national institutions such as ministries supporting climate work or EU institutions initiating carbon neutrality. These influence the actors and activities in the alignment structure but are not in themselves targeting the specific goal of a carbon neutral Helsinki. The external actor goals are of more general goals of fighting climate change. It should be noted that already the sampling of respondents gave an indication of the alignment of actors, as the research topic spans several departments and organizations across Helsinki. Not one respondent had full knowledge of the topic, including the full spectrum of city logistics and sustainability, but the combination of respondents provided a full picture. In the interviews, the actions of commercial entities such as logistics service providers were seen as supporting and enabling e.g., sustainable innovation within the realms of certain projects, but the sole purpose of leaving innovation to the companies was to not interfere with their interests but let them come up with the most suitable innovative solutions themselves (mentioned by SR1, CR3, CR1). The influence of the political city actors on supporting the goals was evident in statements like “we could not do this [sustainability work] without political support” (SR1). The need for political support was also mentioned by CR6 who discussed the interplay with the democratically elected city council and its sub-committees, mentioning the Economic Development Sub-committee that approves the reports and activities of the Helsinki innovation fund that is providing resources for example for the activities of Core01 (mobility lab) and Supp02 (incubation program focusing on innovative and sustainable urban technologies).

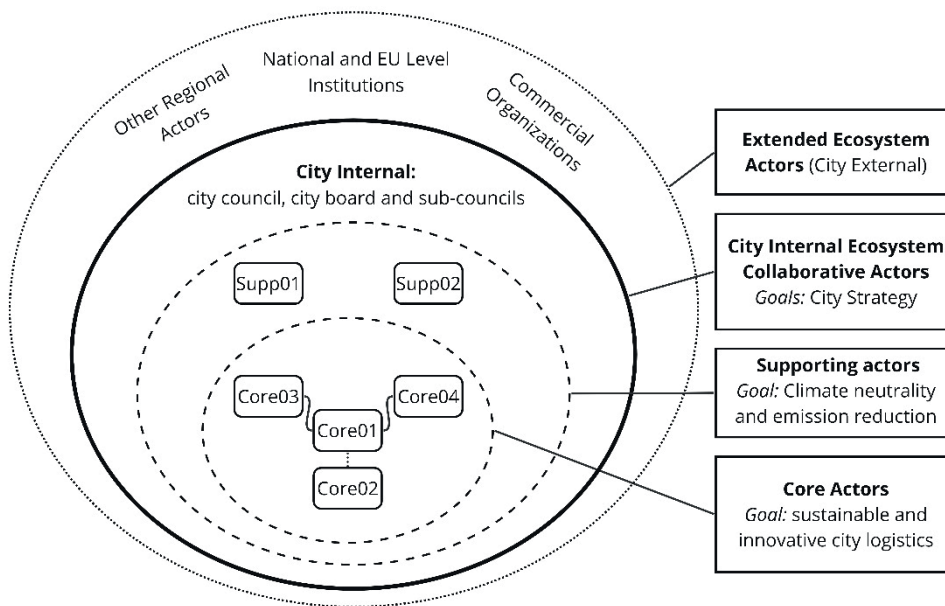


Figure 1 Helsinki city internal actors' ecosystem as a structure aligned with the goal of sustainable city logistics

To understand how the sustainable city logistics goal is manifested in practice sustainable city logistics actions taken by the actors (table 2) were analyzed. Based on the reports and interviews, we observed that in general, Helsinki city has a clear innovation and technology emphasis pertaining to sustainable city logistics. However, at the same time we observed a fragmentation of efforts and a lack of cohesion. The activities supporting the sustainable city logistics goal were taken mainly by 'Core01', the Mobility Lab. This actor leads a collaborative initiative together with Core02, Core03, and Core04. This collaborative initiative between various actors within city of Helsinki operationalizes testing and piloting activities. The main activity is testing and developing smart and digital mobility solutions that promote sustainability. This is a collaborative effort with private sector actors, where the city becomes a "testbed" for their solutions. The importance of utilizing bigger projects that don't limit the activities of companies but leave space for their innovation was highlighted in achieving the greater climate goal of climate neutrality by 2030 (respondent SR1). Respondent SR1 said cities can be forerunners and have a lot of impact on emissions and climate neutrality, while other respondents (e.g., CR1, CR2, CR5) did not see the city as a developer of sustainable solutions, but highlighted market-driven sustainability, where the sustainable development happens in companies that follow a more generic "sustainability trend". One respondent (CR3) mentioned parking policies and other policy instruments outlined in literature (Cardenas et al., 2017), but did not see the city as having a big influence on sustainability.

"Aside from the city's own transportation I don't think the city has much influence over what or how anyone transports anything [...] of course the city can put in environmental zones or similar restrictions and maybe help with the location of distribution hubs." (CR3)

However, all actors agreed on focusing on a goal, be that more sustainability or innovation, and letting commercial players choose the specific activities. In this context, SR3 mentioned that the risk in these scenarios is that the city doesn't get the solutions needed or the most suitable innovations. Another challenge associated with the activities was the project nature of funding and the "personification of projects" (CR4) that hinders long-term development after pilots are concluded. Also, SR1 mentioned they were "allergic to pilots" specifically because these types of activities are hard to scale up. This creates a challenge as, from sustainability viewpoint the built environment, construction and circular economy all came prioritized before logistics and transport, leaving sustainable city logistics development dependent on activities like small-scale pilots. CR6 also said "on the innovation side we must make priorities. You can't do all even if there is demand", saying logistics is not a specific innovation priority. Actions were spread out through actors and reports. For example, last mile was specifically mentioned as a challenge in the Action Plan for City Logistics, but aside from this report, the last mile and most commercial logistics was missing from planning and reporting, and no specific actions were mentioned. On the other hand, the action plan for city logistics did have few and vague sustainability measures. This creates a gap between measures and activities planned for city logistics and the reported measures and action plans for carbon neutrality. All respondents wished for

more sustainable city logistics development, but sustainable city logistics development did not really reside on anyone's desk, creating fragmentation and a focus on only some parts of the city logistics system though limited measures. As Gammelgaard (2015) has previously noted it can be hard to find unified views on common goals in city logistics. In Helsinki the view on the joint goal seems clear, but the execution of the activities is fragmented into small projects.

Table 2 Actor goals and activities aligning with sustainable city logistics

City Goal	Selected Actor Goals	Example activities	Actor(s)
Carbon Neutrality 2030	Smart, sustainable, and innovative urban technology solutions for city logistics	• Testing and developing smart and digital mobility solutions promoting sustainability • Execution and operationalization of pilots • Bringing solutions to be tested in real urban environments and getting input from residents • Incubate promising urban tech startups • Innovation funding (EU and other) • Wide variety of company services • Cooperation and ecosystem building	Mobility Lab (Core01), Forum Virium (Core03), Business Helsinki (Core04), Urban tech Incubator (Supp02)
	Develop sustainable traffic and transport solutions	• Promote electrification (vehicles) • Implementing new service concepts • Land use and city planning • Procurement guidelines • Policy and regulation (e.g., parking, low-emission zones) • Reducing emissions from heavy traffic with equipment choices and environmental criteria	Urban Environment Division (Core02), Climate Unit (Supp01), Business Helsinki (Core04)
	Attract innovative and sustainable ("smart and clean") companies to Helsinki	• Execution of large-scale projects • Helsinki Innovation funding • Distributing EU funds and city innovation funds • Focus on goal and give space for e.g., companies to innovate or execute towards goals, not limiting their specific activities.	Forum Virium (Core03), Business Helsinki (Core04), Climate Unit (Supp01)

As visible in the examples presented in table 2, we observed that in developing city logistics the focus is more on innovation and technology, than it is on sustainability. In this sense city logistics activities are not fully aligned with the overreaching sustainability goals in the Helsinki City strategy. For example, in terms of resources, the Core01 actor (the Mobility Lab) is fully funded by the Helsinki innovation fund and projects are primarily technology oriented. However, implicitly many piloted solutions have sustainability elements like the Shared Micro depots for Urban pickups and Delivery, that focused on enabling deliveries with cargo bikes, that in turn represent low-emission vehicles. Looking at reports and documentation beyond the Carbon neutrality 2030 actions, the city strategy and SDG documentation (of Helsinki, 2023) has a much wider view on sustainability including social aspects and other environmental aspects like biodiversity, but also here innovation is mentioned as a "key way" (of Helsinki, 2023, p. 18) of supporting sustainable development. (Fontaine et al., 2023) has noted that sustainability and profit goals might be conflicting, but in Helsinki, it seems the city is trying to solve this challenge by being innovation and market-solutions oriented in its sustainability work.

Conclusions

Previous research has established the significant role that cities play in the development of sustainable city logistics. However, this case study highlights a potential shift in the city's role. The heightened emphasis on innovation to reach city logistics sustainability may result in a more passive role for the city itself. Rather than actively driving the development of sustainable solutions, the city is increasingly viewed as a platform for commercial entities to develop and implement their own innovative approaches. This is likely to affect the goals and alignment of the internal city actors that create this platform, as there is a discrepancy between the importance of the overall goal of carbon neutrality and anchoring sustainable city logistics solutions to it through actions. The study also provides an example of how the "ecosystem as a structure" (Adner, 2017) perspective can provide a better understanding of how internal city actors and their activities are aligned, by identifying the internal city actors in the city of Helsinki and determining their alignment in terms of sustainable city logistics development. Looking at only one city internal ecosystem provided a possibility to delve into these intricacies, even if the focus is also a limitation of the study, as is the Nordic context. A factor limiting this research is the lack of data on the extended ecosystem, including for example political and commercial actors, and this shortcoming needs to be addressed by further research to fully explore the ecosystem alignment. Future work could also look closer into interdependencies as well as risks involved with goalsetting. The prominent role of innovation also provides ample ground for further inquiries.

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A PRELIMINARY SYSTEMATIC LITERATURE REVIEW OF AGRI- FOOD SUPPLY CHAIN MAPPING PURPOSES AND TECHNIQUES

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Abstract

The aim of this paper is to explore current knowledge on agri-food supply chain mapping. A systematic literature review is presented and addresses two research questions: 1) what are the methods employed in supply chain mapping to ensure they have valid and reliable outcomes and 2) what is the purpose of supply chain mapping in the field of agri-food research? It was found that there is no single preferred approach to conducting agri-food supply chain mapping, with mixed methods research being a common approach. It was also found that agri-food researchers predominantly use supply chain mapping for six purposes: determining strategic advantage, ease of analysis and visual presentations, risk management, circular economy and waste management, prioritisation of activities and traceability.

Keywords: agri-food, supply chain mapping, systematic literature review

Introduction

The ever-increasing complexity of supply chains has resulted in a rise in popularity of supply chain mapping. MacCarthy et al. (2022) list a number of reasons why this technique of visualising supply chain activities has come to the fore in recent years: risks in the supply chain, technological advancement and digitalisation, societal and consumer awareness and expectations, regulation and geopolitics. These authors explain the current stresses experienced by global trade and supply chain activities (e.g., the COVID-19 pandemic, climate change and the War in Ukraine) and go so far as to suggest that supply chain mapping is the principal requirement of any supply chain analysis and yet contend that the technique has largely been overlooked in the scientific literature. While MacCarthy et al. (2022) write about supply chains in general, Septiani et al. (2016) make a strong case for the importance of supply chain mapping in agri-food supply chains. These authors make the point that the perishable nature of products in agri-food supply chains makes them particularly exposed to risks. Furthermore, in a global environment of imbalanced access to safe and nutritious food, food is arguably more valuable than its monetary value as it moves through supply chains to the right destinations, in the right safety and quality and the right quantity. The association with the UNs' sustainability development goals (SDG) cannot be underestimated.

As agri-food researchers with interests in associated supply chains and an acute awareness of current industry challenges, we see great scholarly potential for supply chain mapping in the agri-food context, working towards zero hunger (SDG2) and responsible consumption and production (SDG12), life below water (SDG14) and life on land (SDG15). As such, the objective herein is to undertake a preliminary analysis of current knowledge by conducting a systematic literature review addressing two key questions: 1) what are the methods employed in supply chain mapping to ensure they have valid and reliable outcomes and 2) what is the purpose of supply chain mapping in the field of agri-food research? The overall aim is to gain "a basic understanding of how and why supply chain mapping is conducted so our future work in this sector is theoretically rigorous.

Research design

The process outlined by Tranfield et al. (2003) was adopted for this systematic literature review. Following the identification of the need for this work and the initial planning stages of the review, Figure 1 details the process undertaken in conducting this systematic literature review; subsequently conducted in March, 2023. Supply chain mapping relevant to agri-food networks spans multiple disciplines so four prominent databases relevant to the agricultural sciences and social sciences were interrogated: ProQuest, Web of Knowledge, Scopus and EBSCO Host (known as Business Source Ultimate in the

host online library). The use of these scholarly databases was a technique employed to minimise the inclusion of low-quality works. The initial inclusion criteria were open to any date and any full-text, peer reviewed works.

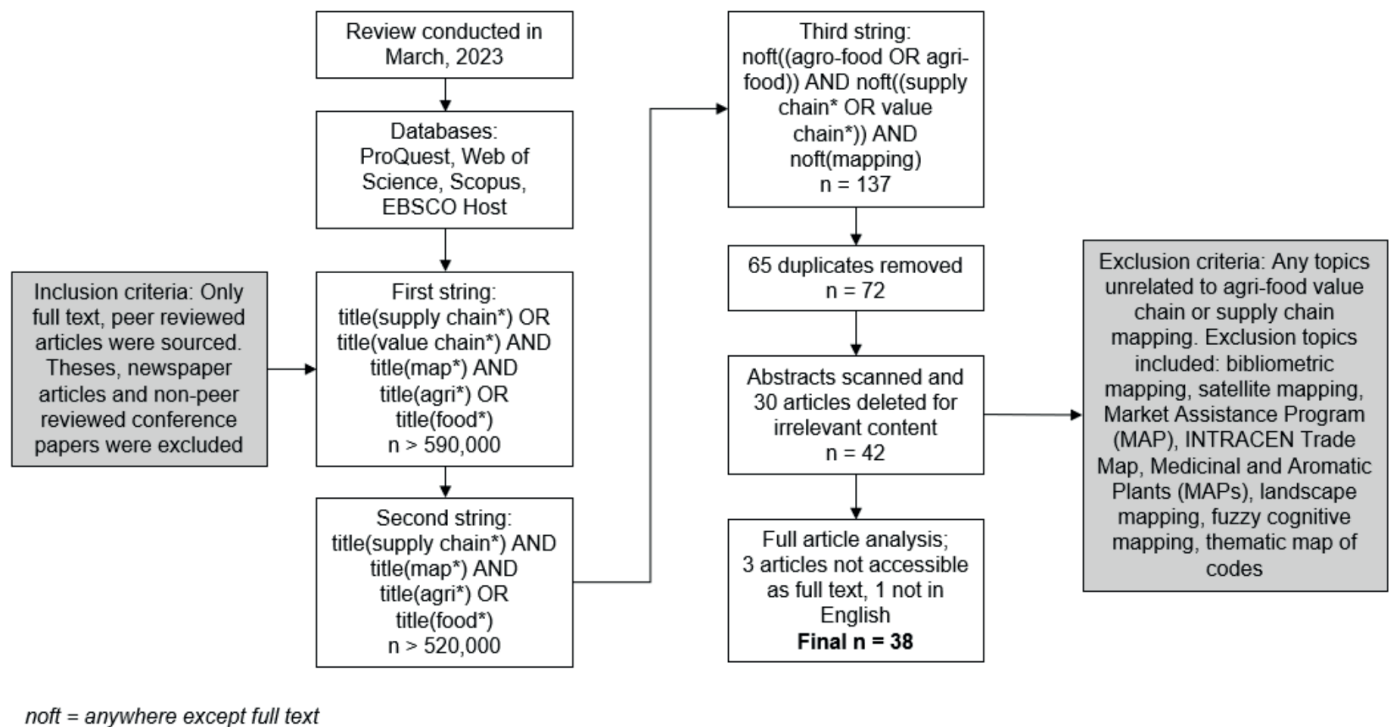


Figure 1: The process undertaken in conducting this systematic literature review

Keywords were selected based on the research questions and the search structure was first selected to determine the scope of current knowledge. The first string was focused on article titles and yielded an unmanageable quantity of results (more than 590,000). The second string excluded the term “value chain” but this also yielded an unmanageable quantity of results (more than 520,000). A review of relevant papers from the searches suggested that search terms related to agriculture might be helpful. As such, the third string broadened searches within the databases (searching anywhere except the full text) but prioritised “agri-food” or “agro-food” as search terms. This yielded a far better sample of 137 works. The results were then reviewed for duplicated works and 65 papers were removed. The abstracts of the remaining 72 works were scanned and 29 works were removed because they contained irrelevant content (related to ‘maps’ or ‘mapping’ as an acronym or an analytical method). Upon reading all 43 works that remained, three works were blocked from online access to full text and one was not in English. As a result, the sample size for this systematic literature review was 38 works.

A full analysis of all 38 articles (listed in the Appendix) was conducted in NVivo Release 1.7.1. (1534) whereby all works were subjected to a content and thematic analysis. The content analysis aimed to address the first research question related to methods used in agri-food”

“supply chain mapping research while thematic analysis was employed to determine the main themes in agri-food supply chain mapping research.

Results

Descriptive analysis

Of the final sample size of 38 works, Figure 2 shows that works captured using the search terms employed were first published in 2006 and there followed a slow but steady rise in popularity until the last reviewed paper was published in 2022. The sharpest rise in publications came during the COVID-19 pandemic in 2019 when the frequency of papers escalated at a very rapid pace. Figure 3 illustrates the distribution of publications of the 38 works. Works featured in 16

different publications but only five of the 16 publications featured more than one paper that matched our search terms. Foods and Sustainability both featured three works each while Frontiers in Sustainable Food Systems, Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development and Sustainable Production and Consumption all featured two works each. All other publications only featured one paper each.”

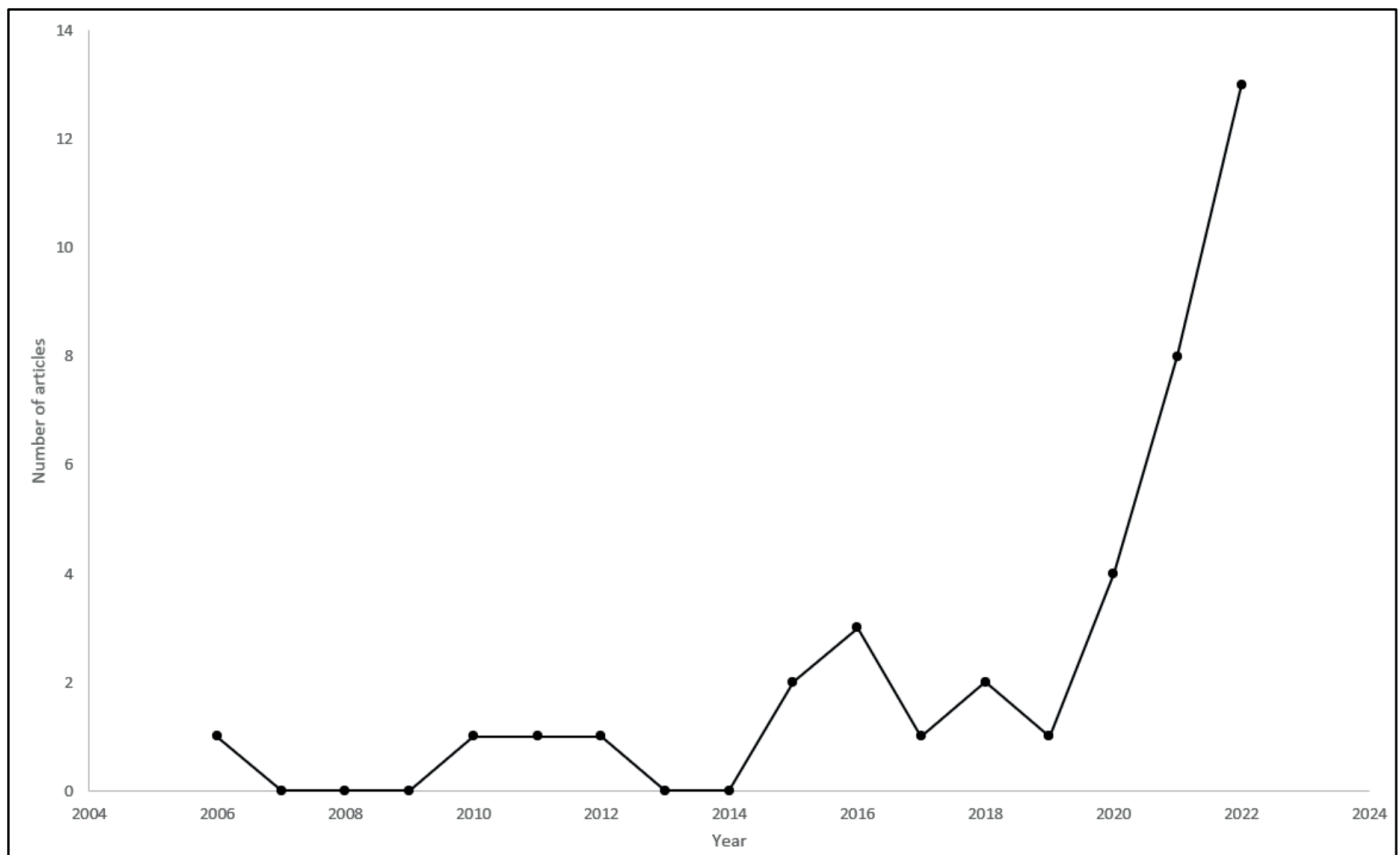


Figure 2: Frequency of works over time (n=38)

It was surprising that publications covering the search terms in Figure 1 have only been available in the past 16 years (since 2006), so a brief analysis was undertaken to determine the quality of this apparently new area of inquiry. Works that resulted from our search are multidisciplinary so established journal quality metrics (such as the ABDC ranking or impact factor) could be considered irrelevant. As such, the SCImago database was used to determine the quality rank of each publication as this database includes both the number of citations for each journal as well as the relative importance of the journal; overall, the SCImago ranking reflects influence rather than quality. The results (in Figure 4) suggest that papers on our search terms are mostly ranked in Q1 journals (n=14). Many works are published in unranked journals (n=8) while fewer are published in Q2 (n=6) and Q3 (n=3) journals.”

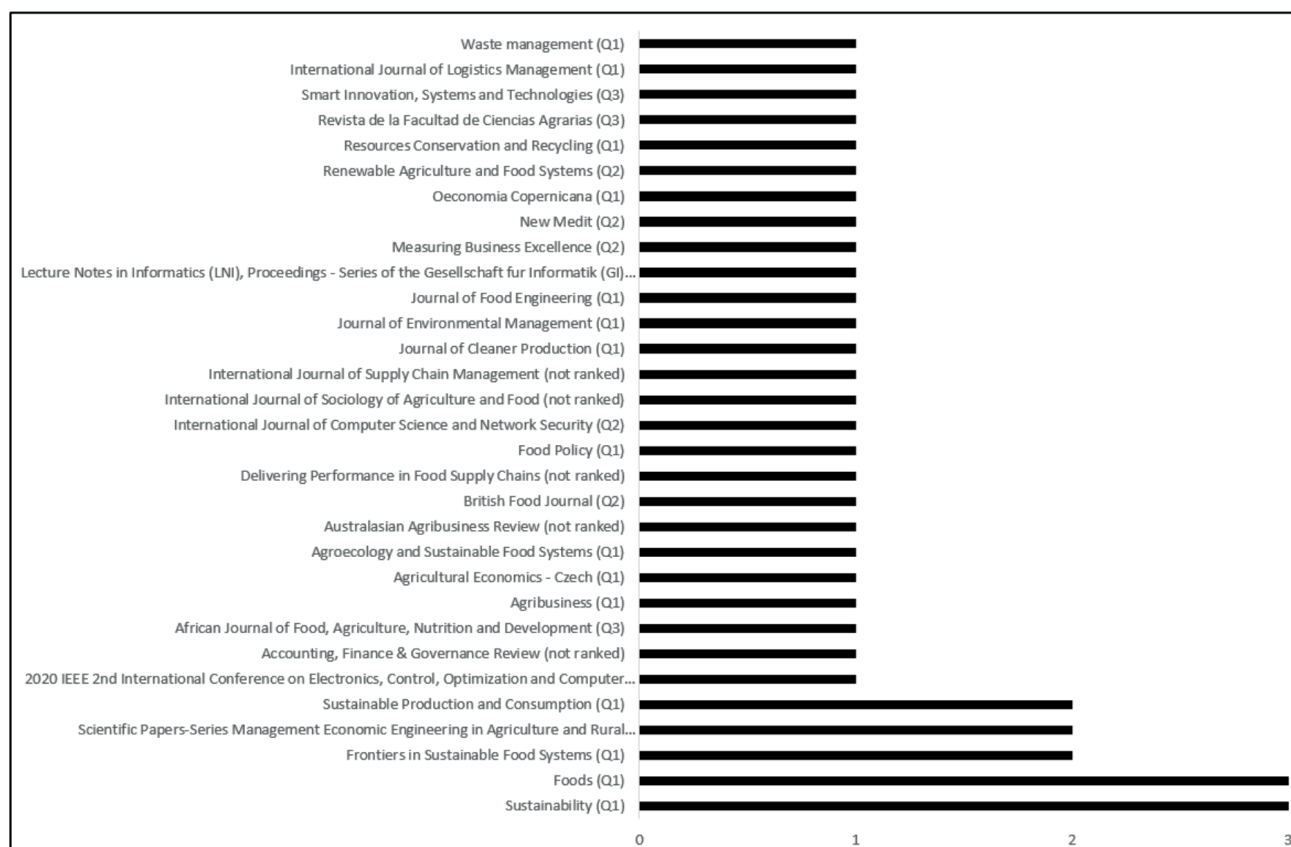


Figure 3: Frequency of papers in peer reviewed publications (n=38)

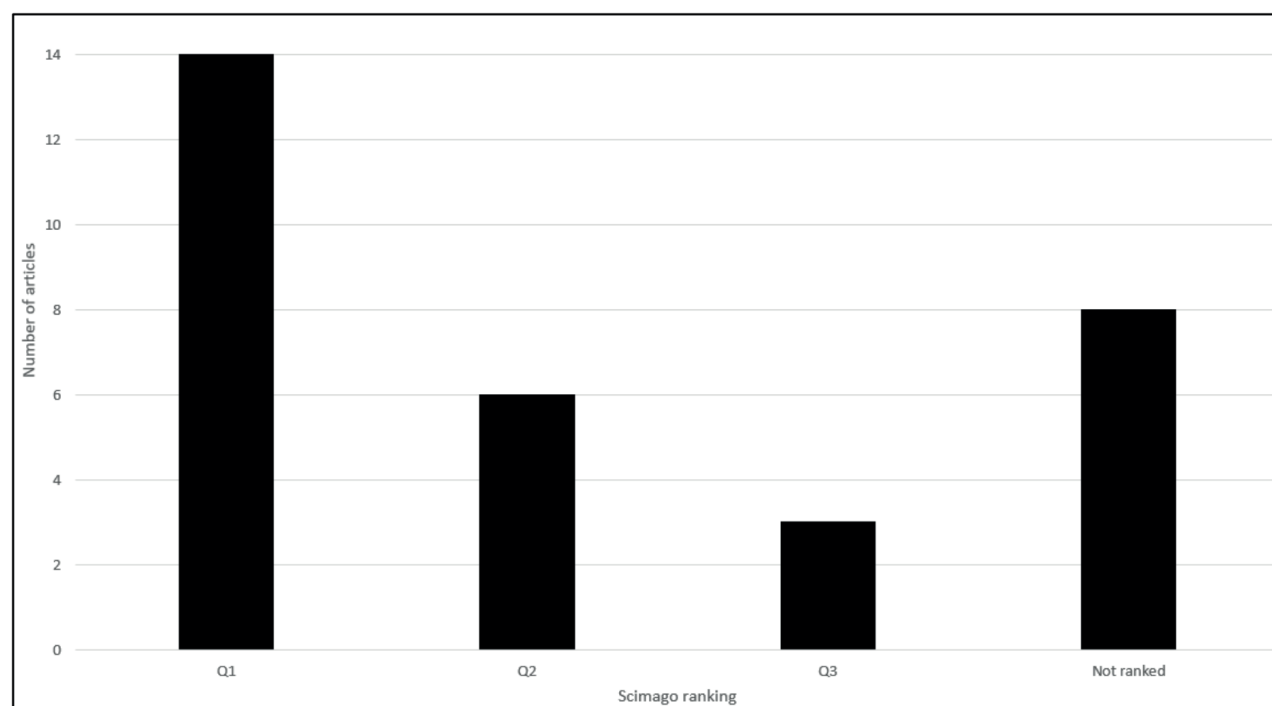


Figure 4: Frequency distribution of publication quality (Based on SCImago ranking)

Thematic findings

The thematic results of the research are presented based on the second research question: what is the purpose of supply chain mapping in the field of agri-food research?

A major research approach to emerge from the 38 works in the sample was various types of literature reviews, systematic literature reviews and bibliometric reviews. In common with the present research, these types of research publications were being used to survey current knowledge on various aspects of supply chain mapping. There were seven references to this type of research approach and the works specifically considered the circular economy, value stream mapping, food security and product-specific mapping like olive oil. Other methods that emerged from the analysis were vastly disparate. Mixed method was a popular approach with few papers employing a mono-methodological approach. Qualitative research in the form of interviews, focus groups and workshops were common as were research frameworks like Life Cycle Analysis (four mentions) and Value Stream Mapping (five mentions). Secondary data analysis, case studies and patent data were mentioned, as were existing software packages to create supply chain maps.

Regarding the second research question about major themes to emerge from current knowledge of agri-food supply chain mapping, Table 1 provides an overview of findings.”

Theme	Frequency of mentions
Determining strategic advantage	23
Ease of analysis and visual presentations	18
Risk management	9
Circular economy and waste management	4
Prioritisation of activities	3
Traceability	3

Table 1: Results of the thematic analysis

Analysis of the works showed that supply chain mapping in agri-food research is predominantly conducted to determine points of strategic advantage (some works discussed comparative advantage while others discussed competitive advantage). Another key purpose of this approach to research is the visual representation of complex systems so they can be easily analysed and communicated. Agri-food supply chain mapping is also conducted to identify contemporary business risks whilst other themes included the circular economy and how waste can be more effectively managed, prioritising and optimising supply chain activities and the use of traceability platforms (e.g., blockchain) for managing information flows.

Concluding discussion

To understand the current state of play in agri-food supply chain mapping, a systematic literature review was conducted. Our findings align with MacCarthy et al. (2022), demonstrating that this method of understanding supply chains is certainly increasing in popularity within scholarly circles with exponential growth of publications occurring since the COVID-19 pandemic when, it could be argued, agri-food supply chains became more complex than ever before. We found that, despite the relative newness of supply chain mapping, it is being featured in some prominent multidisciplinary journals. Our research questions related to common methods in supply chain mapping and it appears that any approach is acceptable with disparate approaches common. Works dedicated to supply chain mapping are largely dedicated to determining where strategic advantage can be found which, of course, harks back to Porter’s (1985) value chain analysis framework. Amongst agri-food researchers mapping is also popularly employed for easily and clearly visually representing the increasing complexity of supply chains as discussed by Septiani et al. (2016). The implication of the research presented here is that this popular approach of analysing supply chains is transitioning from use by consultants to becoming a valid, theoretically rigorous research approach and will be invaluable for addressing many of the UNs’ SDGs. We recommended that this systematic review needs further development. The sample size between the second and third strings is very large so more consideration could be given to refining search terms.

The authors were surprised by the small sample size ($n=38$) so there could be analysis errors to investigate and correct. Finally, as suggested by the title of this paper, the work is preliminary so both research questions could be explored in far greater detail. Deeper investigation could focus on further identifying the classification of methods used for agri-food supply chain mapping and a more detailed, investigative analysis of the themes that emerged from this inquiry.

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Appendix

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VALUE CO-CREATION IN SEAPORT ACCESS MANAGEMENT: AN OPERATIONAL NETWORK PERSPECTIVE

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Introduction

A seaport terminal operator needs to coordinate larger volumes of containers from sea transport—for instance, transported by mega vessels carrying more than 23,000 containers and arriving less than once per week (Ge et al., 2019)—with smaller ones—for example, transported by land-based transport modes such as trains with 120 containers arriving once or twice per week and trucks with just a few containers arriving once or twice per day (Steenken et al., 2004). Given the massive flows of containers from the sea transport that seaport terminals have to process, terminal operators and land transport operators face major challenges (Jeevan & Roso, 2019). The major challenges negatively affect the value for actors involved and can be expressed as inefficient terminal and land-based transport processes (Maguire et al., 2010). For terminal operators, the negatively value is expressed in needless movements and container stacking at terminals (Steenken et al., 2004), slow modal shifts (Woodburn, 2006) and inefficient loading and unloading activities (Sternberg et al., 2013). Such unnecessary movements and container stacking typically occur when trucks arrive unannounced, which prevents terminals from planning for their arrival (Wasesa et al., 2017). In fact, studies have shown that 85–90% of import containers and 60–84% of export containers are needlessly moved and stacked in terminals (Steenken et al., 2004). For land-based transport operators, i.e. road hauliers and rail operators, the negative perceived value is mainly expressed in long turnaround times for trucks and trains (Phan & Kim, 2015).

To address these challenges, the involved actors need to manage their terminal and transport processes effectively (Neagoe et al., 2017) to be able to grant or receive access to the right resources at terminals at the right (Yang, 2016). More specifically, such management, referred to effective access management, coordinates land-based transport resources in conjunction with terminal resources in the right way at the right time (Jacobsson, 2020). Coordination involves interaction of both operand and operant resources. The interaction of these resources in a certain network setup creates co-created value, following the value perspective from service dominant logic (Vargo & Lusch, 2008). Co-created value prompts that value is created among the actors involved rather than viewing value as something offered from one actor to another (Grönroos, 2006). However, the latter is the common view on value in access management literature, where the terminal offers value for access management. This common view has led to services for effective access management lacking consideration of all involved actors value (Islam & Olsen, 2014). Therefore, the current paper prompts the value co-creation perspective to develop efficient access management. Prior research on the sea-side of seaports has shown the value of operant resources for co-created value in maritime logistics (Vural et al., 2019). Nevertheless, even though there exist a few prior research studies on value co-creation on the sea-side part of the port, there exist none (to the best knowledge of the authors) prior research on the land-side part of the port. Therefore, the purpose of this study is to explore operant resources for value co-creation among actors involved to achieve effective access management in a seaport terminal.

Frame of references

Value co-creation in maritime port literature

Value creation in the context of ports has been highlighted from various perspectives in previous freight transport literature. From the traditional value of a port as a transaction node, the ports have developed added value service to become a logistics hub (De Martino et al., 2015). De Martino et al. (2013) explored logistics innovations in ports with a SCM integration focus and found that for port operators to provided value added services, apart from traditional services, there is a need for more interactions with involved actors, such as via information communication technology (ICT). De Martino et al. (2015) investigated value creation in port hinterland by viewing resource allocation and interaction between port and exporter in its hinterland. The paper focuses on setting up rail hinterland connections with the focus on port authority. For port operator joint ventures and partnerships are viewed important for creating value from shared knowledge. Therefore, the paper provides little insights to operational aspects of creating value or service for access management.

Additionally, the view of value holds the presumption that value is created to customers by service provider (De Martino et al., 2015), rather than the co-creation view of service provider providing a number of value propositions to the customer (Grönroos, 2006). The co-creation to achieve value in-use is one of the main points in Service-dominant logic (SDL), where value is viewed to be co-created in interaction between actors in a certain network setup (Vargo & Lusch, 2008). This view has indicated valuable for maritime research, such as from the perspective of maritime logistics networks logistics (Vural et al., 2019) and maritime clusters (Hammervoll et al., 2014). De Martino (2021) made a theoretical contribution by taking a strategic perspective on ports for value cocreation with focus on sustainable values. Including value co-creation implications for operations is limited in port maritime literature. Acciaro et al. (2018) studied success for innovations in port operations. The authors found interactions between actors as one key factor for improved results from innovation. Di Vaio and Varriale (2020) similarly found increased value from digital platforms for port business process management by shared and digital information between actors.

Value co-creation in seaport access management

Access management refers to managing the process by which actors access resources at terminals, and effective access management can be achieved when access to the right resources at terminals at the right time is granted or received by exchanging the relevant information at the right time (Jacobsson, 2020). When relevant information is exchange at the right time among actors involved, for example agreeing on timeslots when trucks and trains are to be arrived at the terminal, value is created for terminal operators since they can better plan arrivals of trucks and value is created for road hauliers and rail operators with decreased turnaround times (Phan & Kim, 2015). However, even though turnaround times can be decreased, road hauliers and rail operators experience problems with insufficient timeslots and less flexibility since they simply wish to arrive at their destinations and do not want another constraint to be at a terminal at a certain time (Islam & Olsen, 2014). Therefore, to accomplish co-created value and in turn achieve effective access management, the actors involved should interact with additional resources than only the exchange of relevant information.

Resources in previous access management research include operand resources such as vessels, trucks, trains, employees, loading lanes, straddle carriers, cranes, employees and containers (Woxenius, 1998), as well as operant resources such as information communication technologies (ICTs), information technology (IT) and information systems (Almotairi et al., 2011). Operand and operant resources need to be viewed from a hierarchical perspective to comprehend the value of the resources (Madhavaram & Hunt, 2008). In other words, to grant or receive access to an operand resource (e.g. a loading lane), an interaction of operant resources (e.g. information sharing and exchange) among involved actors need to take place. Namely, when interaction among such resources is achieved, value is created (Madhavaram & Hunt, 2008). Vural et al. (2019) found 7 categories of operant resources with different importance for the value co-creation process. The categories included business impact power, communication skills, corporate dependability, organisational competence, process and network management dexterity, service intelligence integration skills and service vigour. These categories include 41 operant resources. Examples of the operant resources are credibility and employee capability with trust (Kohtamäki et al., 2013), process improvement capability (Cancelas et al., 2021), information-sharing capability and information-processing capability (Almotairi et al., 2011), customers orientation with clear incentives (Kohli & Grover, 2008), relationships among actors (Håkansson et al., 2009), and reputation value co-creation (Vural et al., 2019).

Consequently, effective access management can be achieved when value is co-created among actors involved through their interaction of additional operant resources than only information sharing and exchange that in turn can grant or receive access to the right operand resources at the right time.

Method

A qualitative single case approach was used to get in-depth understanding (Flick, 2014) around different actors' perspectives during the development phase of effective access management. The case covers the port side and land side of container transport via one of the largest container ports in the Nordic countries. The actors involved include one terminal operator, one road and rail operator, one road haulier, one rail operator, one information system supplier and one OEM. The case was chosen to represent the network of involved actors in access management operations of terminal operator, hauliers and rail operators. The case was conducted in the scope of a research project aiming to establish digital solutions, such as application programming interfaces (APIs) (Inkinen et al., 2019), at each actor to enable automatic digital real-time information exchange to achieve effective access management. The initial plan to implement APIs could not be finalised but

the relevant information was exchanged as Excel-files via emails among the actors. So, the project achieved information exchange for access management operations but did not achieve full implementation of APIs. Therefore, the lessons learned could be captured from a value co-creation perspective to underline interaction of operant resources.

As co-creation of value involves interactions in a certain network setup, six focus groups and four telephone meetings were conducted with the involved actors focusing on how, what and when relevant information needed to be exchange as well as status updates regarding its process. The data collection via focus groups aims at gathering experts to discuss a specific topic (Flick, 2014). After the performed focus groups and telephone meetings, the data was analysed following the operant resource category framework by Vural et al. (2019). The analysis included categorizing the collected data into the different operant resources for current state of access management. Thereafter, the data was used to classify the implications of the operant skills for effective access management, that is how the operant resources influence the co-created value for access management. The analysis was done in Excel and performed by both authors to keep track of analysis and hedging misunderstanding from one author. To validate the analysis, meetings with the individuals that participated in the focus groups from rail operators were performed. During these meetings the results for each operant resource category were presented and confirmed or changed depending on the responding input.

Results and analysis

A summary of all operant resources categories with corresponding resources and their importance for value co-creation is found in Table 1. The operant resources categories are listed from top to bottom depending on the number of "X":s each category gained.

Operant Resource Category	Operant Resource	Important for value co-creation
Organisational competence	Adaptation skills	X
	Credibility	X
	Employee capability	X
	Internal competence	X
	Shipment planning capability	X
	Technological competence	X
Process and network management dexterity	Global service capability	-
	Know-how and experience	X
	Organizing skills	X
	Proactiveness	X
	Problem-solving capability	X
	Process improvement capability	X
	Process integration skills	X
	Process visibility	X
Service intelligence integration skills	Customized service generation capability	X
	Information-processing capability	X
	Information-sharing capability	X
	Intelligence generation	X
	Knowledge integration	X
Service vigour	Market intelligence generation	-
	Customer orientation	X

	Risk-sharing convenience	-
	Service flexibility	-
	Service reliability	X
	Speed of response	X
	Value creation mindset	X
Corporate dependability	Environmental & social compliance capability	-
	Ethical employee behaviour	-
	Requirement reliability	X
	Risk commitment	-
	Service support consistency	X
	Trustworthy business attitude	X
Communication skills	Personal contact accessibility	-
	Personal interaction skills	-
	Relationship-based initiatives	X
	Requirement expression skills	X
Business impact power	Negotiation power	-
	Network guidance power	-
	Market share power	X
	Reputation	X
	Strategic stand	-

Table 1 Operant resource categories important for value co-creation

In the organisational competence category, all (six out of six) operant resources are important for value co-creation in access management. Each actor needs adaptation skills for internal processes to achieve effective access management by avoiding sub optimal value, i.e., administration burden at hauliers end. Credibility and employee capability are illustrated via the importance of trust and understanding between actors and their processes. Trust is underlined in prior research since it increases the effectiveness of value in a network (Kohtamäki et al., 2013). The understanding of other processes is important to see the dependencies between different actors' operations. The internal competence and technological competence for co-creation revolve around IT skills, since access management is based on exchanging relevant information.

In the process and network management dexterity category, seven out of eight operant resources are important for value co-creation. The interaction of resources of know-how and experience in the network constellation serve both to establish information sharing between actors as well as utilising information to be quick on changes and proactive, connecting to the resources of proactiveness and problem-solving capability. Regarding the process improvement capability resource, each actor needs to adopt their processes for value co-creation to achieve effective access management. Namely, as also highlighted by Cancelas et al. (2021), the actors must adapt their processes according to the information that is exchanged. Moreover, due to the interdependencies between the actors' operations there is a need for process integration skills between the actors to achieve effective access management. Lastly, all actors need to show what they know about the operations to achieve process visibility. Visibility from information sharing is a cornerstone in achieving effective access management.

In the service intelligence integration skills category five out of six operant resources are important for value co-creation. Customized service generation capability is important when choosing access management service to implement. Information-processing capability and information-sharing capability are important operant resources for co-created value and cornerstones to achieve effective access management. Well-functioning information-processing capability and information-sharing capability rely on information communication technologies (ICTs), information technology (IT) and information systems (Almotairi et al., 2011). If the involved actors are not able to process and share information between each other, an effective access management is difficult to be achieved. Knowledge integration can be accomplished by, for example, creating a demonstration video that shows how the access management services are to be used.

In the service vigour category, four out of six operant resources are important for value co-creation. Customer orientation is important when choosing the right access management service to implement. In terms of service reliability, the terminal operator needs to keep service promises as access management services imply increased burden for road hauliers to share information as booking timeslots. To motivate road hauliers to book timeslots, incentives regarding their improvements and advantages need to be clearly generated and stated. Prior research has also highlighted the importance in understanding the incentives of all actors involved for co-creation value (Kohli & Grover, 2008). By following the same reasoning for the service reliability, the speed of response is important in terms of accessing the right container at the right time for effective access management. Finally, the value creation mindset is important for all actors' value creation where all actors need to have a value-oriented mindset and approach.

In the corporate dependability category, only three of the six operant resources are important for value co-creation. The requirement reliability is important when setting up what and how information is to be exchanged among actors. For example, application programming interfaces (APIs) are important when exchanging information among actors involved without the need of replacing their existing information systems with new ones (Inkinen et al., 2019). The actors involved believe that the service support consistency is important to assure effective access management. The trustworthy business attitude is important where all actors involved must follow it from start to end of the process and between network alliances.

In the communication skills category, only two out of the four operant resources are important for value co-creation. Relationship-based initiatives can be important when for example conducting pilots to test access management services. Relationships are important processes that develop, change and evolve over time and affect actors, resources and activities (Håkansson et al., 2009). The requirement expression skills are important since they do not only affect how and what information is to be exchanged but also are important to adapt the processes accordingly.

In the business impact power category, only two of the five operant resources are important for value co-creation. These two are market share power and reputation. The container handling for vessels in the terminal has higher priority than for rail and road. The terminal operator has specific KPIs coupled to vessels that tells how efficient the terminal operator is. The reputation is important and where long TTTS affect the reputation negatively. Namely, a terminal's reputation is positively impacted by decreased TTTS and by increased speed of information processing (Russo & Gronalt, 2021).

If the operant resources marked with an "X" in Table 1 would have been interacted among the port operator, the rail operator and the road hauliers, value could have been co-created that in turn could have led to effective access management among the actors involved. Even though the initial ideas of implementing APIs at each actor could not be accomplished in this study, effective access management could not be achieved without the interaction of the identified operant resources. Namely, to accomplish value co-creation the identified operant resources need to be interacted and not only the exchange of relevant information. For instance, for value co-creation all actors involved also need to change and adopt their processes according to the information that is exchanged. This change and adoption of the processes can, for example, lead to that personnel need to be educated to be able to handle and react upon the information as well as planning, allocating and resources in other and efficient ways.

As a result, effective access management cannot be achieved by only exchanging relevant information at the right time, but identified resources need also be interacted among actors involved. Even though APIs can enable digital automatic real-time information exchange, it is not sufficient in achieving effective access management. Therefore, a broader view where identified operant resources are interacted needs to be considered to co-create value among all actors involved that in turn can result in effective access management.

Conclusion

The purpose of this study was to explore operant resources for value co-creation among actors to achieve effective access management in a seaport terminal. The actors involved are terminal operators, rail operators and road hauliers.

From a theoretical perspective, this study enriches the literature on seaport management by adding service dominant logic perspective on value co-creation and expresses the need for interactions of operant resources among actors involved to achieve effective access management. Moreover, this study also adds to the prior literature on effective access management that is limited to exchange of relevant information at the right time (as stated in prior research studies) by the identified operant resources that also need be interacted among the actors involved.

From a managerial perspective, this study also contributes to decision-makers with the new knowledge around effective access management that exchanging information is not the issue but the actors need to make sure that they act upon the exchanged information by incorporating into their processes and educate their staff accordingly. In other words, no effective access management is achieved as long as the information is not taken under considerations and the processes are changed accordingly.

Although the identification of 29 operant resources that need to be interacted among actors involved, our findings indicate avenues for further research that can add nuance to our results. Namely, future research should focus on identifying which of the operant resources that must be interacted to achieve effective access management. For example, is it enough will only some of the operant resources or must all of them be interacted? As a suggestion, a survey may be conducted where the 29 resources are quantitatively examined through different statistical analyses. Furthermore, more actors such as shippers and forwarders may be included to investigate if similar results are found.

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THE IMPACT OF CIRCULAR ECONOMY METHODOLOGIES ON SUSTAINABLE LOGISTICS PERFORMANCE

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1 Introduction

In today's volatile environment, creating sustainable logistics performance requires the highest attention and the most immediate action (Ding et al., 2023); The growing popularity of the circular economy and the general concept of same has attracted relatively little attention in supply chain, logistics and operations management journals (Liu et al., 2018; Hazen et al., 2021). The current literature indicates that empirical research on the correlation between circular economy and supply chain, logistics management is scarce (Hazen et al., 2021). At the same time, there is a lack of empirical evidence on introducing circular-based supply chain logistics into the real-world context (Le et al., 2022). In addition, there is a shortage of literature as a bridge between circular economy and supply chain, logistics management (De Angelis et al., 2018). However, some notable reviews have begun to inform the relationship between supply chain logistics and the circular economy. For instance, Liu et al., (2018) carried out a theoretical review on the further link between the circular economy and green supply chain, logistics. In doing so, they particularly focus on academic literature. Furthermore, Hazen et al., (2021) conducted systematic literature reviews regarding the intersection between the circular economy and supply chain logistics. These findings reveal not only the lack of literature bridging circular economy and supply chain logistics, but also the necessity to focus on empirical research and examine the remains of lack of detailed understanding in the literature regarding what impact the circular economy has on sustainable logistics performance. Developing this understanding is the primary aim of this research paper. This paper also answers a call from Banihashemi et al., (2019) and Javed, et al., (2021) that there is a need for research on the impact the circular economy has on sustainable logistics performance (Banihashemi et al., 2019 and Javed, et al., 2021). The proposed model seeks to fill a research gap focusing on the growing need for more research to be conducted on the impact circular economy methodologies have on sustainable logistics performance (Al Koliby et al., 2022).

The paper is structured as follows: Section 1 contains a general introduction. Section 2 presents our literature review. Section 3 develops various hypotheses. Section 4 sets out the methods adopted to construct the study. Section 5 discusses the result of our analysis. Finally, Section 6 summarises our findings and highlights the potential for further research.

2 Literature Review

This section provides a short introduction to the two main concepts addressed in this research, Circular Economic Methodologies (CEM) and Sustainable Logistics performance (SLP). Starting with the former and concluding with the latter, this section briefly introduces the historical origins of these two key concepts, draws comparisons, synthesises important definitions, and discusses the relevance of these two concepts.

2.1 Circular Economy Methodologies

The CEM have been gaining popularity over the past decade, sparking the interest of both academia and practitioners. A circular economy methodology is a process or activity which reduces emissions, waste, and primary resources (Mendoza, et al., 2017; Kravchenko et al., 2020). These CEM work simultaneously to reduce the environmental impact of an operation, such as logistics (Scheel et al., 2020). Logistics is a large contributor to waste and pollution (Traini, et al., 2022), CEM can transform this essential operation to eliminate the negative impacts it has on the planet (Van Fan et al., 2019). It provides the opportunity to create a sustainable future, where carbon emissions are reduced. (Walker, et al., 2022). According to previous academic studies, there are five main methodologies linked to the circular economy. These methodologies are collecting resources, manufacturing, distribution, use, reuse, followed by the opposite flow, which includes remanufacturing and reverse logistics, which are repeated again and again (Bernon et al., 2018; Asif, et al., 2021; Mendoza, et al., 2017). The CEM have a direct impact on logistics in terms of environmental, economic, and social sustainability (Bag, and Gupta, 2020). The most important CEM in logistics which requires further research is reverse logistics and remanufacturing (Östlin et al., 2008, Agrawal, and Singh, 2019).

Remanufacturing (RM)

Remanufacturing is an important methodology in the circular economy, it determines the extent to which the materials and products can be used again by customers once the original product has reached the end of its life (Wang et al., 2018; Lieder, and Rashid, 2016). RM is important in logistics performance as it prevents stock shortages (Vasudevan et al., 2012), reduces material consumption, use and cost (Jiang et al., 2019), reduces lead times of resource for production (Jinru, et al., 2022), decreases emissions and need for packaging (Javed, et al., 2021). Scholars argue that RM has a positive impact on logistics social sustainability performance by increasing loyalty between supply chain members, job creation, and, enhancing brand image (Östlin et al., 2008; Tang and Zhou, 2012; Fofou et al., 2021). It impacts environmental logistics sustainability performance, because it provides the possibility for the re-use or re-development of waste goods, so that they may form part of the supply chain again. (Bag et al., 2019; Bag and Gupta, 2020).

Reverse logistics (RL)

RL involves the operation of transporting and waste materials and products to be reused, and or remanufactured (Gregson et al., 2015). RL methodology is the most common and efficient practice for achieving a circular economy in relation to the distribution and RL of materials (Alamerew and Brissaud, 2020). RL methodology is not only environmentally beneficial, but also economically sustainable as it reduces transportation and holding costs. Furthermore, RL is beneficial for social sustainability between the business and its customers. The customer values not having to dispose of waste, and being able to identify themselves as well as the other stakeholders with a business that has a good brand image (Manninen, et al., 2018). However, RL creates uncertainty in the supply chain and does not just hinder the economic aspects of business, but the social aspect as well, because it creates distrust (Wang and Chan, 2021). RL in the circular economy is complex, it impacts logistics performance (Mallick et al., 2023).

2.2 Sustainable Logistics Performance (SLP)

Logistics sustainability performance includes waste, transport, manufacturing, and warehouse management, as well as resource usage (Yontar, 2022). Logistics is involved in all of the phases and methodologies of the circular economy, they are vital, and they require indicators which measure performance, in order to be developed and identify when sustainability is achieved (de Souza et al., 2022). Performance indicators are extremely significant during and after the implementation of the circular economy principles and logistics practices. Performance indicators enable performance to be assessed on the basis of targeted achievements (Kazancoglu et al., 2018; Karaman et al., 2020). The indicators used in this paper, just like those used in other research, are: the performance of logistics environmental, economic, and social sustainability (Ali et al., 2018; Suleiman, 2022).

Logistics Economic Sustainability Performance (LESP)

Logistics economic sustainability performance refers to how the logistics circular economy operations perform, in relation to how to achieve logistics economic sustainability (Ding et al., 2023). Logistics impact the economic sustainability of firms in a significant way, due to the potential of efficiency, low costs, and effective operations, if implemented correctly the business will be fruitful (Arsić, et al, 2020). Logistics economic sustainability includes not only cost savings, but also increased market share, and sales by adopting modern operational techniques (He et al., 2018).

Logistics Social Sustainability Performance (LSSP)

Logistics social sustainability performance is how the logistics circular economy operations which are socially sustainable perform, in regard to achieving logistics social sustainability (Agyabeng-Mensah, et al, 2021). In order for social sustainability to be achieved, the partnerships and relationships between the various stakeholders must be of high quality for all parties to succeed (Mani and Gunasekaran, 2018). Circular economy operations such as RL achieve logistics social sustainability, it creates trade-offs such as increased customer satisfaction and improved public relations, which enables social sustainability to be achieved. (Sarkis et al., 2010; Javed, et al., 2021).

Logistics Environmental Sustainability Performance (LENSP)

Logistics environmental sustainability performance is how the logistics circular economy operations which are environmentally sustainably perform, in regard to achieving logistics environmental sustainability (Lee and Wu, 2014). In transportation using fuels such as bioethanol, biodiesel, biogas, compressed natural gas, electricity, and hydrogen powered vehicles can reduce emissions as these can be sustainably sourced (Zhao et al., 2020). Sustainable warehousing in logistics uses renewable energy for powering the lights, machinery, and equipment within the facility (Deckert, 2020). Sustainable warehousing includes waste reduction within processes through minimising use of packaging, and pallet movements in the warehouse (Burinskiene et al., 2018).

3 Hypotheses Development

The following hypotheses as seen in Table 1, have been developed based on the supporting literature which provides both justifications and compelling arguments. Primary research will be conducted to confirm or deny whether or not these hypotheses are true. Proposed model Figure 1 displays the relationships and correlations between the hypotheses which is to be revisited in the findings section of this paper.

Table 1 Hypothesis Development

No.	Hypotheses	Sources
H1	The remanufacturing methodology has a positive impact on logistics environmental sustainability performance.	(Del et al., 2021; Dey, et al, 2020; Jinru, et al., 2022).
H2	The remanufacturing methodology has a positive impact on logistics economic sustainability performance.	(Del et al., 2021; Dey, et al, 2020; Jinru, et al., 2022).
H3	The remanufacturing methodology has a positive impact on logistics social sustainability performance.	(Del et al., 2021; Dey, et al, 2020; Jinru, et al., 2022; Östlin et al., 2008).
H4	The reverse logistics methodology has a positive impact on logistics environmental sustainability performance.	(Dey, et al, 2020; Javed, et al., 2021; Suleiman, 2022; Ali et al., 2018).
H5	The reverse logistics methodology has a positive impact on logistics economic sustainability performance.	(Dey, et al, 2020; Javed, et al., 2021; Suleiman, 2022; Ali et al., 2018).
H6	The reverse logistics methodology has a positive impact on logistics social sustainability performance.	(Dey, et al, 2020; Javed, et al., 2021; Suleiman, 2022; Östlin et al., 2008; Ali et al., 2018).

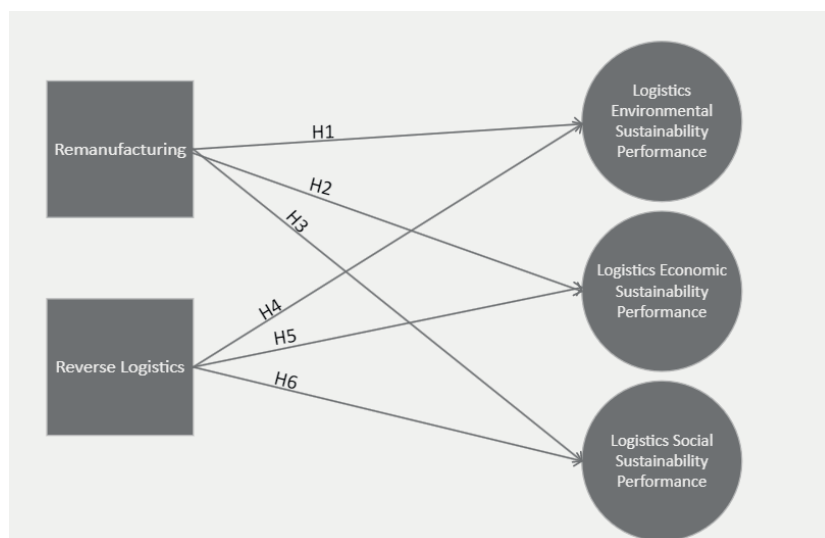


Figure 1 Proposed Model

4 Research Methodology

4.1 Questionnaire Design and Measures

The main instrument for conducting the survey is the questionnaire that is developed based on the guideline of Elangovan and Sundaravel (2021). The steps in developing the questionnaire were carefully performed to ensure the questionnaire's appropriateness to the study's scope. In terms of measurement, this questionnaire aims at measuring the practices and behaviours of firms in the field. Multi-item measures were developed based on existing scales in the literature after a series of interviews with supply chain managers working with logistics companies in Ireland. Minor modifications to wording were made to adapt it to our research context. All items were measured on the 5-point Likert scales where higher scores indicated higher levels of agreement or better performance.

4.2 Sampling and Data Collection

A total of 104 questionnaires were developed and administered to Irish logistics industries through Microsoft Survey. The survey implementation strategy was guided by Dillman (2000); Gazzola et al. (2020). A personalized email was sent to each firm, ensuring confidentiality of the results, including a link to the survey, and offering a results summary upon completion. We focused on senior management in these firms and obtained email addresses from the organizers' LinkedIn. A key informant approach was used with the senior supply chain executive in each firm approached to undertake the study. These individuals were chosen due to their knowledge of their firm, their access to key information, familiarity with the circular economy and their experience with sustainable supply chain and logistics (Suleiman 2022). This approach has been widely used in empirical studies in a supply chain, logistics context (Baah et al., 2022; Let et al., 2022; B). A pre-survey conversation with a randomly selected sample of 15 firms confirmed the suitability of the firms for this research.

4.3 Data analyses

In this study, the analytical technique used is SPSS 28 and Mplus 8.7 because of its suitability for models with complex structural relationships. The model of this study includes direct, indirect, mediating and regulatory relationships and is therefore considered a complex model (Hair et al., 2017). In terms of the characteristics of the sample from SPSS 28 results, as presented in Table 3. To assess potential late response bias, we compared early and late respondents, the age of their companies, and their employee numbers (Armstrong and Overton, 1977).

Table 3 Sample Characteristics

Number of Employees	%	Company Age	%
10 or less	5.8	Less than 1 year	1.9
51-100	9.6	1-3 years	1.9
101-300	21.3	4-8 years	6.7
301-500	7.7	9-12 years	5.8
Over 500	55.6	Over 12 years	83.7

Company Sale Revenue in the Past Year	%	Stakeholder Involvement in the Company	%
Less than 50,000	2.9	3 rd Party logistics Company	68
51,000-100,000	1.0	Business Partner	16.4
101,000-150,000	2.0	Government	1.9
151,000-200,000	3.9	Independent	9.6
201,000-250,000	1.9	Local government & Business Partner	4.1
Over 251,000	88.2		

n= 104

According to the Conformity Factor Analysis (CFA), RL is a second order construct, then principal component analysis with varimax rotation was run for factor loading analysis. As a result, two factors were observed. We analysed our data using Structural Equation Modelling with MPlus 8.7. The measurement model including all constructs had a good level of fit (, degrees of freedom (df) = 109, root mean square error of approximation (RMSEA) = 0.077, comparative fit index (CFI) = 0.93, Tucker-Lewis index (TLI) = 0.941, standardized root mean squared residual (SRMR) = 0.048). Table 2 depicts the items, their means, standard deviations and their reliabilities using composite reliability (CR) and average variance extracted (AVE).

Table 2: Item Loadings and Reliabilities

RL (CR = 0.743, AVE = 0.496)	Mean	SD	Loadings
RL1: Our firm accepts product returns from customers?	3.91	1.270	0.827
RL2: Our firm recalls products with quality problems?	3.91	1.380	0.567
RL3: Our firm returns products to suppliers?	4.06	1.131	0.695
RM (CR = 0.963, AVE = 0.868)			
RM1: Re-manufacturing involves inspecting all modules and parts in the product.	3.24	1.318	0.883
RM2: Remanufacture involves disassembly up to part level?	3.11	1.277	0.978
RM3: Remanufacture involves product upgrade up to as-new quality level?	3.17	1.310	0.957
RM4: Re-manufacturing is the work of returning a product to at least the original equipment manufacturer performance specification.	3.12	1.264	0.907
LSSP (CR = 0.890, AVE = 0.671)			
LSSP1: Our firm improves community health and safety?	3.88	1.112	0.726
LSSP3: Our firm improves the occupational health and safety of employees?	4.39	.886	0.864
LSSP4: Our firm improves awareness and protection of the claims and rights of people in the community served?	4.14	.939	0.768
LSSP5: Our firm reduces environmental impacts and risks to the general public?	4.14	1.047	0.906
LESP (CR = 0.878, AVE = 0.706)			
LESP3: Our firm has growth in market share?	4.05	1.083	0.760
LESP4: Our firm has growth in sales?	4.22	.985	0.909
LESP5: Our firm has growth in profit?	4.23	1.017	0.846
LENSP (CR = 0.903, AVE = 0.757)			
LENSP3: Our firm has overall improvement in an enterprise's environmental situation?	3.96	.975	0.829
LENSP4: Our firm reduces air emission discharged to the environment?	3.85	1.139	0.913
LENSP5: Our firm decreases the frequency of environmental accidents?	3.95	1.065	0.867

Discriminant validity was tested in Table 3 and Table 4, and all inter-construct correlations were below the lowest square root of the AVE's, the p-values for H1 and H2 were slightly above 0 but still support the hypothesis, however, the H3 result was above 0.05 which does not support the value. The p-values of H4, H5, and H6 were 0 which shows they are strongly supported.

Table 3 Correlation Matrix

	RL1	RM	LSSP	LESP	LENSP	Size
RL1	1					
RM	0.328***	1				
LSSP	0.603***	0.26*	1			
LESP	0.537***	0.42***	0.554***	1		
LENSP	0.5***	0.394**	0.701*	0.496***	1	
Size	ns	ns	0.196**	0.16*	0.25**	1

Notes: *p<0.1; **p<0.05; *p<0.01; ns = not significant**

Table 4 Loading and Reliabilities

	Structural Path (relationship)	Standardised Loadings	Est/SE	P-value	Result
H1	Remanufacturing LESP LESP	0.262	0.095	0.006	supported
H2	Remanufacturing LENS	0.242	0.095	0.011	supported
H3	Remanufacturing LSSP	0.060	0.097	0.535	Not supported
H4	Reverse Logistic LESP	0.484	0.099	0.000	supported
H5	Reverse Logistics LENS	0.476	0.100	0.000	supported
H6	Reverse Logistics LSSP	0.620	0.090	0.000	supported

Model Fit: Chi Square=175.808 (df=109), RMSEA=0.077, SRMR=0.048, CFI=0.953, TLI=0.941

The study utilized Structural Equation Modelling to examine the relationships between two sustainable logistics practices: RL and RM, and the three dimensions of logistics sustainability performance, i.e., economic, environmental, and social. The analysis was based on a sample size of 104. The findings supported H1 and H2, indicating that RM has a positive and significant relationship with both LESP and ENSP with standardized loadings of 0.262 and 0.242, and p-values of 0.006 and 0.011, respectively. However, H3 was not supported, as the p-value of 0.535 and of the standardized loading was only 0.06, indicating no significant relationship between RM and LSSP.

In contrast, RL was found to have a positive and significant relationship with all three dimensions of logistics sustainability performance, supporting H4, H5, and H6. The study also found that the control variable of Company Size had a significant positive impact on both LSSP and LENS. In contrast, the control variables of Company Age and Revenue were insignificant, contrary to the conceptual model. The model fit indices indicated an acceptable model fit, with a Chi-Square of 175.808 (df=109), RMSEA of 0.077, SRMR of 0.048, CFI of 0.953, and TLI of 0.941. These results suggest that the proposed model provides an adequate fit to the data, and the relationships among the variables in the model are reliable, it refers to Figure 2.

In summary, the findings provide support for the significance of sustainable logistics practices in improving logistics sustainability performance, particularly in the areas of economic and environmental sustainability. The results also suggest that RL is a crucial factor for achieving sustainability across all three dimensions, while RM has a significant impact on economic and environmental sustainability but not on social sustainability. Moreover, controlling for company size is crucial in understanding the relationship between sustainable logistics practices and sustainability performance, while company age and revenue may not be significant factors.

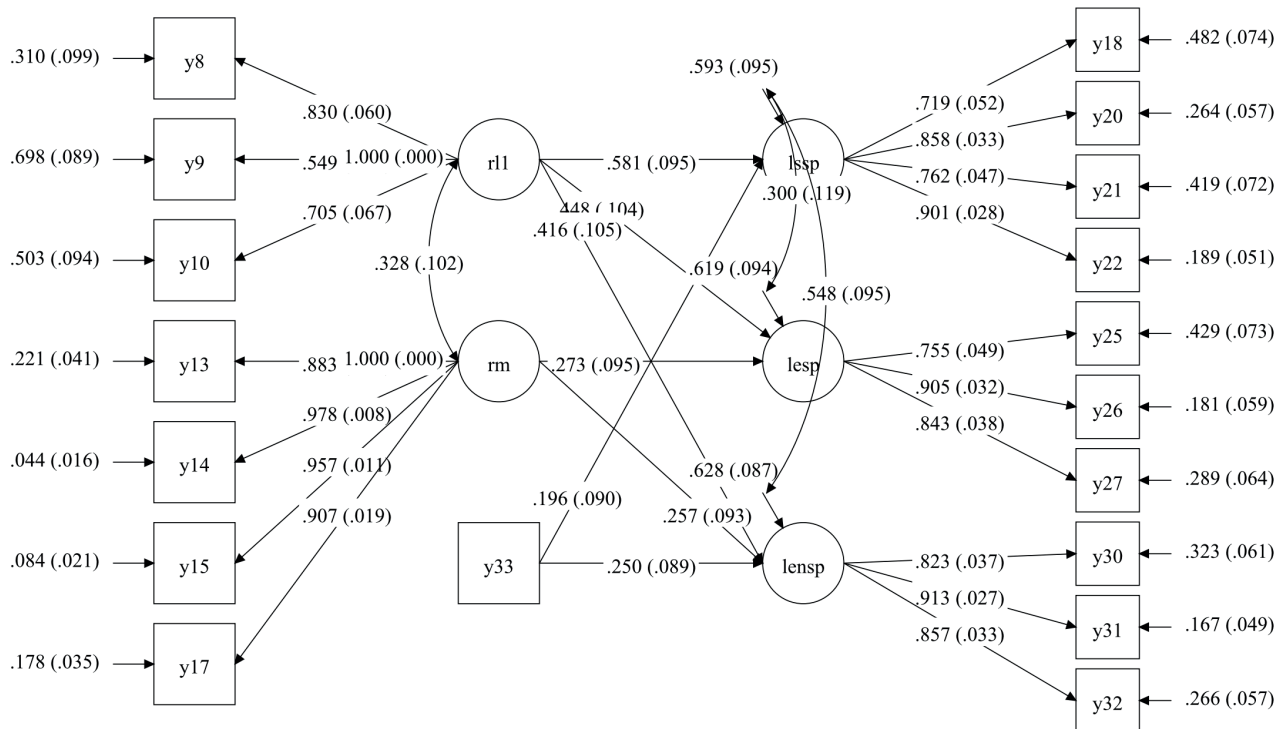


Figure 2 Testing Model

5 Discussion and conceptual framework/ Findings and discussion

Previous literature on RM conducted by Yan, et al., (2018); Cheng et al., (2023); and Yenipazarli, (2016), state RM does not have a significant impact on LSSP. This corresponds to the primary data collected in this paper. Previous research conducted on RM aligns with the primary data in regard to its positive impact on LENS, and LESP in Ireland. (Jiang et al., 2019; Javed, et al., 2021; Jinru, et al, 2022;). Literature on RL's impact on LENS, LSSP, and LENS, aligns with the primary data collected in this research, it is supported that RL has a positive impact on all three dimensions of SLP (Manninen, et al., 2018; Javed, et al., 2021; Makarova, et al, 2021). Interestingly, through conducting this primary research, additional theory has been developed within this topic. This additional theory is that RM has no positive impact on LSSP. Literature by Yenipazarli, (2016), found similar results, that RM does not have an impact on LSSP, due to the fact that there is no social aspect of this circular economy methodology.

6 Conclusion, contribution and future research

In summary, this paper highlights the significance of CEM in improving logistics sustainability performance, particularly in the areas of economic, social, and environmental sustainability. The hypotheses H1, H2, H4, H5, and H6, were supported by our primary research, H3 was not supported. The results suggest that RL is a crucial factor for achieving sustainability across all three areas of logistics sustainability performance. From a theoretical perspective, our research contributes by developing a framework in CRM and SLP, it also provides implications of the study, which can be used as a 'signpost' for further research. These research findings offer important managerial contributions and suggestions concerning management relevant issues. Managers must also focus more on sustainable logistics performance to develop circular economic methodologies. As RL only tested two dimensions, future research can analyse the mediating role of RL on the CEM and SLP, to acquire a greater understanding and reasoning behind the CEM of RM and RL, and their impacts on LSSP, LENS, and LESP. Specifically, regarding the indirect relationship between RM and LSSP.

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CONCEPTUALISING ELECTRIFIED LOGISTICS SYSTEMS THROUGH AN ACTOR PERSPECTIVE

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Introduction

Climate change forces the logistics sector to take initiative to reduce the use of fossil fuels since transport contributes to a large part of today's emissions of greenhouse gases (Lopez-Behar et al., 2019). Using electric trucks is one way that can reduce emissions (Dahlgren & Ammenberg, 2022) and especially for the long-haul heavy-duty trucks, the effect in reducing emissions has large potential (Alp et al., 2022). Electric trucks can be charged in different ways, for example connecting to electric roads (Shoman et al., 2022) or by battery swapping (Wu et al., 2021), but this study focuses on electric trucks with stationary charging which means that the truck carries an onboard battery which can be charged at a public charging station or at depot (Kin et al., 2021).

Common actors in a logistics system are logistics companies such as forwarders and hauliers. With the changed situation with electric trucks, the actors will face different challenges. For example, logistics companies may be affected by reduced payload according to heavy onboard batteries which directly have impact on driving range (Alp et al., 2022), and hauliers might have difficulties in financing the trucks since investment costs is higher, compared to diesel trucks (Noll et al., 2022). Also, electrification of trucks requires new actors to join the system (Fenton & Kailas, 2021), such as actors who provides electricity and charging opportunities (Löfstrand et al., 2013). For them, it is important to develop an efficient charging infrastructure with high utilization to be able to cover high investment costs for grid development (Noll et al., 2022). Given the novelty of the area and the lack of actor perspective (Gillström et al., 2022), other actors may also become important. Some of them will have a more central role and some will work more in the periphery, but all will have a role necessary to make the system functioning.

Indeed, there exist many uncertainties regarding which actors that are expected to take a role and how the role of existing actors can change in future electrified logistics systems. To provide a more comprehensive understanding of electrified logistics systems, this paper conceptualises the relation between actors and logistics systems, departing from the three-layer model presented in Wandel et al. (1992). The model introduces material flow, transport flow, and infrastructure as three separate layers. Describing logistics systems through the perspective of actors, and how they connect to the system is vital to understand the role of different actors and how actors are connected to each other. Therefore, the purpose of the paper is to describe electrified logistics systems through an actor perspective.

Frame of reference

Electrification

Replacing diesel trucks with electric counterparts is often viewed as an important step in reducing emissions (Nicolaidis et al., 2019), and electric motors have fewer moving parts, which mean easier and cheaper service (Li et al., 2022). Like diesel trucks need to refuel, electric trucks need to charge the batteries. For long-haul deliveries, the likely charging set-ups is to have charging possibilities at the start and end nodes, but also during route (Alp et al., 2022). Other benefits of switching to electric trucks comprise of potential to reduce the operational cost, and lower noise level during use (Noll et al., 2022). However, as with all transitions, several downsides exist that affect both the actors who are performing the deliveries, but also in the larger actor network. The most commonly mentioned barriers are more limited range (Noll et al., 2022), which, for example, affect logistics companies; increased investment cost of the trucks (Li et al., 2022), something that can have a large impact on multiple actors; need for infrastructure for charging, which concerns investment costs, locations for the chargers, and available effect (Alp et al., 2022); uncertainties regarding second-life and residual value of the trucks and batteries (Noll

et al., 2022); and risk of loss of payload and flexibility of deliveries (Li et al., 2022). Indeed, barriers may challenge how the transport can be executed, but also involvement of different types of actors and the connections between them.

Actors in logistics systems

Logistics systems comprises of different actors; however, the type of actors and the relations can differ depending on the contexts for which the logistics systems are to support. In this section, some such contexts and their inherent actors will be presented.

Three of the most central actors in logistics systems are transport buyers, forwarders, and hauliers (Nilsson et al., 2017). The authors make an important point of larger forwarders often hire hauliers to perform transport assignments and raises the question how the responsibility shift regarding environmental sustainability. In the specific context of city logistics, Ballantyne et al. (2013) propose a model consisting of ten actors, distinguishing between those that have an interest in the logistics system, and those that have actual influence on the system. Not surprisingly, transport buyers, called shippers, and freight transport operators (including both forwarders and hauliers) are recognised as actors with an influence on the system, thus being central actors. For this specific context, authorities, and customers, such as end-consumers, are also deemed as central actors. Less central actors, i.e. those with an interest in the system, are, for example, vehicle manufactures, authorities, and property owners. Sallnäs and Björklund (2020) highlight logistics companies, retailers (or e-tailers, as labelled by the authors), and consumers as the most central actors in greening of freight transports in an e-commerce context. In yet another context, specifically construction logistics, Fredriksson and Huge-Brodin (2022), identify three categories of actors; municipalities, contractors and developers. The traditional logistics actors can be found within the contractor category, where transport buying actors as well as construction specific logistics companies are found. The other two categories, however, contain actors that are specific for the context of construction logistics systems, such as traffic planning, urban planning, architects, and clients.

From the perspective of electrified freight, the above-mentioned actors can have central roles. Further, there are likely to be actors commonly not part of logistics systems that need to take important roles, in line with Ballantyne et al. (2013) and Fredriksson and Huge-Brodin (2022). Examples of these actors are grid owners, energy suppliers, and charge point operators (Alp et al., 2022; Löfstrand et al., 2013). Indeed, given the novelty of the area, there exist uncertainties about which actors are central in future electrified logistics systems.

Layers of logistics systems

In 1992, Wandel et al. (1992) proposed a model on how transport systems can be conceptualized using a three layer-model. The layers represent the material flow, the transport flow, and the infrastructure. Between each layer, the authors introduced different types of markets, where supply and demand meet. The first market, the transport market connects the material flow and the transport flow (Wandel et al., 1992). The demand from material flow relates to type and amount of goods in need of transport, and the supply from transport flow concerns type of vehicle and which activities are performed (Behrends, 2012). Common evaluation measurements of the transport market are effectiveness and efficiency (Irfani et al., 2019; Wandel et al., 1992). The second market, the traffic market connects transport flow and infrastructure. Physical infrastructure includes placement of roads and intersections and mainly concerns policies and decisions from authorities (Wandel et al., 1992). The three-layer model has been applied in different contexts logistics researchers since first introduced by Wandel et al. in 1992. Recently, Fredriksson and Huge-Brodin (2022) applied the model to conceptualise how actors are involved in different layers in a construction logistics setting. The authors modified the model to fit the context, which resulted in a five-layer model. Urban land use was a new layer, while transport layer was divided into two different layers (construction and construction supply chain). Urban land use is separated from infrastructure partly due to the strong connection to the construction layer (Fredriksson & Huge-Brodin, 2022).

Research method

The purpose of this paper is to describe electrified logistics systems through an actor perspective. Thus, as actors are a central part, capturing their view is important and has guided the choice of data collection methods. As a first step, interviews of an exploratory nature were held, as these were considered as a good starting point to familiarize with the

subject at hand (Patel & Davidson, 2011). Indeed, the actor perspective has been lacking in the electrification literature (Gillström et al., 2022), and there was thus a need to gain an initial understanding of different actors' perspectives. As a second step, focus groups were organised. Contrary to the interviews, the focus groups aimed at capturing the views of a multitude of actors simultaneously. Focus groups is a suitable method when the aim is to understand the how a group of participants respond to each other's views, not only considering its own position (Bryman & Bell, 2015).

Data collection and analysis

Four interviews were held with representatives responsible for logistics planning at three organizations (two logistics companies and one transport buyer). In one case, two interviews were held with representatives from the same organization since the responsibilities related to working with electrification were shared. All interviews were performed digitally with two researchers present. The interviews were transcribed and sent to the respondents for them to verify the material, which increase the credibility and reduced the risk for errors (Halldorsson & Aastrup, 2003). The interviews were of semi-structured nature (Patel & Davidson, 2011), which fitted the scope and exploratory nature, and covered background questions such as structure of their vehicle fleet and transport assignments; the organizations work with electrification; and their relationships with other actors. An interview guide with the questions was sent out beforehand.

Four focus groups which were held digitally have been carried out with participants representing a variety of actors who actively work with electrification, such as companies from the transport sector, truck manufacturers, energy companies and public sector. In total, 28 participants participated during the focus groups, and they were divided in four groups with 5-10 people in each group. Each focus group started with providing the participants with information regarding the setup and purpose, something highlighted as important by Bryman and Bell (2015). The focus groups were divided into different steps and a digital whiteboard-resembling tool – Flinga – was used to enable the participants to work together simultaneously. For all groups, one researcher led the discussions, while a colleague took notes, which enabled traceability (see e.g. Halldorsson & Aastrup, 2003). The first step comprised of participants identifying actors that they deemed relevant in an electrified logistics system. In the next step, the participants prioritized the actors regarding how central they are, using a colour scheme. In the last step, the participants highlighted important connections between the actors to highlight how actors are connected.

The analysis consisted of two parts. The first part was to cluster the identified actors based on the interviews and focus groups. The clustering was performed by two researchers who, through discussions reached consensus regarding which actors belonged to which cluster. The process was mainly inductive, but the researchers' knowledge of the area also played a part. The second part was to conceptualise the connection between actors and logistics systems based on the findings, using the layer-model presented in Wandel et al. (1992). The actors identified in part one formed the basis for this analysis, and the conceptualisation connected actors to the layers and how the market between each layer can be affected when transitioning to electric logistics systems.

Results

The result from the interviews and focus groups is listed in Table 1 and shows the actors that the participants found central in electrified logistics systems sorted in five groups according to their focus in the logistics system. The actors shown in italic were highlighted as the most prominent actors by the workshop participants, whereas the others were considered as more peripheral. Worth mentioning is that the terminology used varied between the respondents and in the focus groups it was clear that different people use different words for describing the same actor. Working in a group eased the way of using the same word and limited the need of interpretation by the researchers.

Truck and battery	Transport	Energy supply	Authorities	Other
<i>Truck manufacturer</i>	<i>Forwarder</i>	<i>Charging point operators (CPO)</i>	<i>EU</i>	Terminal owners
Truck workshop	<i>Transport buyer</i>	<i>Grid companies</i>	<i>Government</i>	The rescue service
Investment partners	<i>Haulier</i>	<i>Energy supplier</i>	Local politicians	Insurance companies
Second life operators	Truck terminal	<i>Charging infrastructure manufacturer</i>	Municipality requirements	Consumer
Vehicle body builder	Drivers	IT-suppliers	Public sector	Salvage companies
Battery manufacturers	Landowners	Traffic authority		
		E-mobility service providers		

Table 1: Categorisation of central actors in electrified logistics systems

As presented, all actors having a central role in logistics systems according to Nilsson et al. (2017) are represented also here and are still considered to have a central role in the electrified logistics system. Interestingly is the visibility of new actors in the other four groups and especially the ones that is considered to have more central roles as truck manufacturers, CPOs, grid companies, energy companies, EU and the government. The actor group 'Other', will also have a role in making the system work but as they were not mentioned by all the respondents and was therefore not considered to have a central role in the system.

Conceptualising an electrified logistics system

The point of departure was the three layer-model presented in Wandel et al. (1992) to describe logistics systems by connecting actors to it. However, as the results showed, electrified logistics systems with its actors become more complex thus a need to expand the model. Actors occurring in the model from 1992, such as transport buyer, forwarder, haulier, and regulators are still relevant and are expected to have similar role and placement in the model. However, the findings and previous literature related to greening of freight deliveries (Alp et al., 2022; Fredriksson & Huge-Brodin, 2022; Sallnäs & Björklund, 2020) show the need to expand the scope of actors, and the results point to a corresponding situation for electrified logistics systems. Two examples from such systems are companies who own the power grid and companies that supply the energy. Grid owners can potentially directly affect placement of chargers and available effect. The placement of chargers needs to consider where the large freight flows are in order to reach high utilization (Noll et al., 2022). In a similar vein, energy companies were highlighted as important during the focus groups since they control available effect at charging locations, and to achieve well-optimized logistics systems it become very important to have sufficient power at the charging stations to reduce the stand-still time of trucks as much as possible. This calls for new relationships between an actor that are not part of logistics systems today and logistics companies.

Another type of actor that is worth highlighting is the OEM, which can be different types of companies, such as truck manufacturers and charging infrastructure manufacturers. Truck manufacturers have of course a central role in today's systems, but results from the focus groups pointed to that they will have a much-changed role in electric freight systems. For example, it is expected that the specification of electric trucks requires more interaction between truck manufacturers and buyer of trucks, i.e. the logistics companies. This is due to limitations such as range and cargo capacity (Noll et al., 2022) must be accounted for and that the trucks must fit within logistics companies transport assignments (i.e. new prerequisites regarding the supply and demand). It also becomes important for logistics companies to secure that the potential loss in flexibility and loss of cargo do not affect their business, especially since the freight industry is often highlighted as cost-pressured with low margins (Nilsson et al., 2017), further highlighting the importance of interaction between logistics companies and truck manufacturers. The other type of OEM, charging infrastructure manufacturers, become important in similar fashion as energy suppliers, i.e. enabler for sufficient effect at charging locations. The discussions during the focus groups point to that their role is not clear since they can have interest in the system (more passive role) or having more influence (more active role), following the logic presented in (Ballantyne et al., 2013). Either way an understanding between the supply of equipment and the demand related to effects is needed.

Indeed, it is clear that new types of actors become vital and that the three-layer model (Wandel et al., 1992) in the current state is not sufficient described to connect actors that are relevant for electrified freight. To handle the increased complexity and based on the discussions above, two new layers are proposed: Hardware development and charging network (see figure 1). The placement of the layers follows the logic presented in the previous sections and based on connection between actors within different layers, i.e. markets, following the terminology used in Wandel et al. (1992). One important note to make is the differentiation between infrastructure layer and charging network layer. Based on the original model and its applications (Behrends, 2012; Fredriksson & Huge-Brodin, 2022; Wandel et al., 1992), the infrastructure layer mainly concerns regulators and the type of policies needed. While this is also very much relevant in electrified logistics systems and policies can affect future investments in charging infrastructure, it is also very different responsibilities and actions compared to the responsibilities in the actors in the energy network layer.

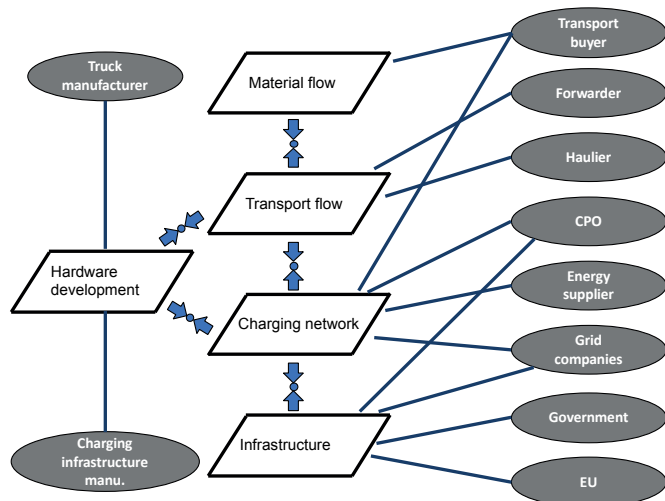


Figure 1: Illustration how the more central actors are connected to the layers of logistics systems.

Conclusion

Reaching a better understanding of electrified logistics systems from an actor perspective is central to ease the transition from fossil trucks to electric trucks. The result illustrates which actors that will have central roles in electrified logistics systems. Specifically, they show that traditional logistics actors, such as logistics companies and transport buyers, will keep their central roles, and that they will be accompanied by new central actors, such as providers of electricity, manufacturers of trucks and batteries. To further understand the actors in the logistics system, a proposed conceptualisation of electrified logistics systems, including two additional layers to the original model by Wandel et al. (1992).

The research at hand adds to the literature within electrification by expanding and nuancing the actors involved in electrified logistics systems. This is vital, as the actor perspective has been given surprisingly little attention in the literature. Further, the paper provides an expansion of the model originally developed by Wandel et al. (1992), thus contributing to the logistics literature.

The paper can help bringing knowledge to the actors mentioned in this paper and help them to understand their role in electrified logistics system which could ease the transition from fossil trucks to electric trucks.

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THE CASE FOR RESILIENT SUPPLY CHAINS IN THE AGE OF SCOPE 3 REDUCTION MANDATES

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1. Introduction

One of the world's most pressing needs is carbon neutrality by 2050 (Guterres, 2020). It is estimated that about 50% of global emissions are caused by eight supply chains (SC) including the fast-moving consumer goods (FMCG) industry (Burchardt et al., 2021). With countries across the world beginning to mandate the disclosure of emission data for larger businesses, the regulatory landscape is undergoing a tectonic shift. As Scope 3 emissions comprise up to 90% of the emissions generated in (FMCG) supply chains (WEF, 2021), effective reduction strategies with a cross-organisational focus become indispensable. For the FMCG industry, increased sustainability requirements can result in a trade-off between emission reduction goals and business objectives in terms of cost and responsiveness (Thei en et al, 2014). This research therefore explores the challenges to implementing sustainable supply chain practices for managing Scope 3 emissions and discusses recommendations for handling different categories of Scope 3 to improve emission management practices and create resilient supply chains with profitable sustainability.

2. Literature Review

2.1 Scope 3 Emissions in Supply Chains

Most companies traditionally focus on reporting and managing direct emissions from their operations - Scope 1 and Scope 2 - as these are typically measurable and in direct control of the focal firm. However, with the rapidly depleting global carbon budget, the focus is shifting to reducing emissions from indirect sources (i.e., Scope 3) which are generated during the product lifecycle (SBTi, 2018). As per Patchell (2018), failure to account for Scope 3 emissions can result in serious underestimation of a company's climate change impact and prohibit management from implementing effective mitigation and supply chain resilience strategies.

According to the GHG Protocol Corporate Value Chain Standard Scope 3 emissions can be sub-divided into fifteen reporting categories (cf. Figure 1).

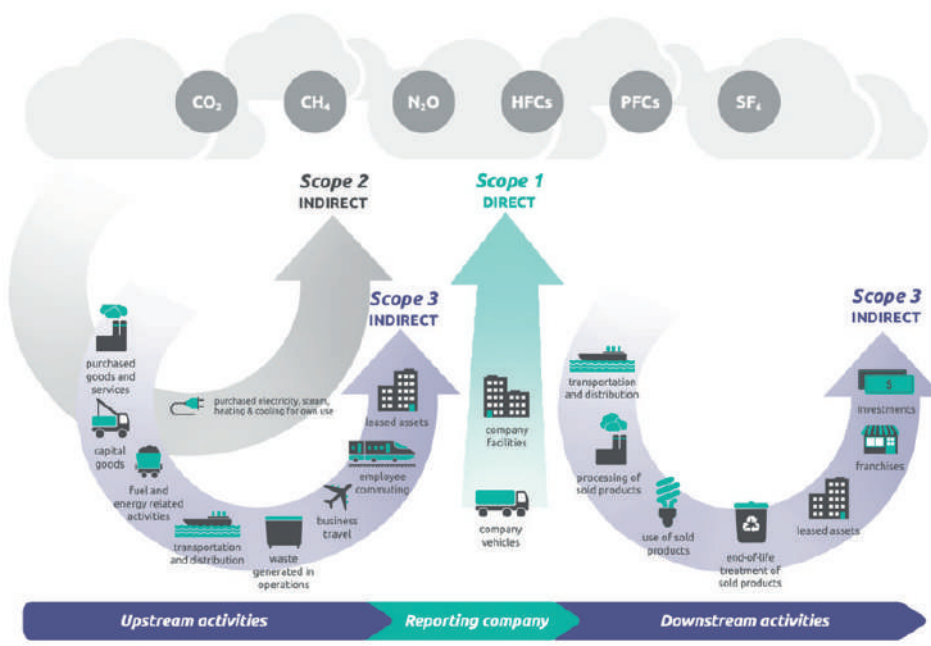


Figure 1 : Scope 3 emissions reporting categories. Source: Green House Gas Protocol Scope 3 Accounting Standards

Due to its recent urgency, the disclosure of Scope 3 emissions is naturally less mature and more limited as compared to Scope 1 and 2 (Santoro, 2023). Some of the notable initiatives and frameworks include the Science Based Targets initiative (SBTi), the Task Force for Climate-related Financial Disclosures (TCFD), the EU Corporate Sustainability Reporting Directive (CSRD), the US Securities and Exchange Commission (SEC), International Sustainability Standards Board (ISSB), Sustainable Finance Disclosure Regulation (SFDR) which mandate indirect Scope 3 emissions reporting by companies thereby gain competitive edge.

2.2 Measurement of Scope 3 Emissions

Although the methodology of calculating Scope 1 and Scope 2 emissions is well established (Santoro, 2022), indirect Scope 3 emissions are not as easily measurable. According to the Greenhouse Gas Protocol for Scope 3, four approaches are commonly used for quantifying Scope 3 emissions including spend based, supplier based, activity based and hybrid approaches.

Another layer of complexity is caused by the qualitative nature of the GHG Protocol's criteria for identifying relevant Scope 3 activities (SBTi, 2018). Categories which are easier to calculate (i.e., Business Travel) get reported more often than the bulk emission categories which are more difficult to calculate (CDP, 2023). The industry has many different organisations angling to develop frameworks like PCAF, UNFCCC, API, BHP, as well as commercial data providers (Busch et al, 2018).

2.3 Challenges

Existing research highlights that one of the main barriers to Scope 3 emission reduction is the lack of supply chain visibility (Timmermans, 2021; Jannink et al., 2022). As per Burchardt et al. (2021) the issue could be exacerbated for companies with large supplier base or with many tiers of suppliers. Research suggests that consumer goods margins could shrink as much as 30% by 2030, unless supply chains are reinvented to meet these requirements (Kwasniok et al., 2020). Companies will therefore have to develop capabilities suitable to overcoming these supply chain vulnerabilities to strike a balance between investment and risk also referred to as 'balanced resilience' (Pettit, Fiksel and Croxton, 2010). Ahi and Searcy (2013) therefore suggest expanding the sustainability characteristics to an integrated perspective, including not only the environmental, social and economic perspective, but also resilience along the focus on stakeholders, volunteers and long-term performance. Henrich et al., (2022) offer a similar perspective to say that future proofing supply chains will require a combination of resilience, agility and sustainability to retain competitive advantage.

Other challenges cited in existing literature include high transaction costs, data uncertainty and the need for industry wide collaboration across complex value chains for Scope 3 emission computations (Patchell, 2018; Wu, Chuang and Hsu, 2014). In addition, Melville (2019) found four common barriers including costs, lack of expertise, lack of awareness and understanding Scopes of emissions as well as a change resistant mindset at the industry level. As a comprehensive Scope 3 emissions computation involve extensive supplier engagement, even companies disclosing comprehensive Scope 3 data may struggle to translate those efforts into lower emissions due to the involvement of external supply chain partners (Mahapatra et al., 2021).

3. Methodology

Semi-structured interviews were used to gather the data for this research as they allow for an in-depth exploration of the research objectives (Saunders, Lewis and Thornhill, 2019). Interviewees were selected to cover the end-to-end spectrum of i) supply chain companies as adopters, ii) software companies as enablers and iii) consultants as facilitators who work with diverse clients to identify best practices and foster organisational learning (Table-1). Participants were selected according to a purposive sampling approach to "obtain the broadest range of information and perspectives on the subject of study" (Kuzel, 1992, p. 37). To compare contrasting views, people working at the grassroots level as well as the higher management were selected as participants. The lack of standardisation in semi-structured interviews can lead to data quality concerns like biases, cultural differences or validity (Saunders, Lewis and Thornhill, 2019). This research accounted for common method bias by following the procedures outlined by Podsakoff, MacKenzie, and Lee (2003). Interviewees were informed of their anonymity to rid 'temptations for respondents to be more socially desirable or consistent'. In order to limit interviewer bias, the questions and tone of the interviewer were kept strictly neutral to avoid attempting to impose own beliefs or frame of

reference through the questions asked. Multiple interviews were conducted to get a holistic perspective from professionals having FMCG work experience in the area of supply chain sustainability and/or Scope 3 reduction each lasting no more than 60 mins.

No.	Current Job Title	Professional Experience of working in supply chains	Industry	Geography
1.	Executive Vice President SCM	>25 yrs	FMCG Supply Chain	Netherlands
2.	Director of Climate and Energy	>15 yrs	FMCG	USA
3.	Co-Founder Carbon Management Platform	> 18yrs	Supply Chain	Germany
4.	Category Manager-Offshore Installations	>10yrs	Oil & Gas Supply Chain	India
5.	Consultant- Sustainability & Climate Change	5-7yrs	Big Four Consultancy	India
6.	Consultant- Sustainability & Climate Change	5-7yrs	Big Four Consultancy	India
7.	Consultant- Sustainability & Climate Change	< 7yrs	Big Four Consultancy	India
8.	Senior Manager-Sustainability & Climate Change	7-10yrs	Big Four Consultancy	India
9	Analytics Product Owner	5 -7 yrs	Oil & Gas (Ex Supply Chain)	India
10	Product Owner Carbon Platform	5-7 yrs	Carbon Management/ Energy	UK

Table-1: Interview Participant Information. Source: Author

1. Data Analysis

After reviewing a range of data analysis methods, thematic analysis was chosen as it can be used both for analysing small data-sets with 1–2 participants (Cedervall and Åberg, 2010) as well as large interview studies with 60 or more participants (e.g. Mooney-Somers, Perz, and Ussher, 2008). Following Saunders, Lewis and Thornhill (2019), Thematic analysis is a method for identification, analysis and subsequent interpretations of patterns ('themes') within qualitative data. Braun and Clarke's (2006) 6-step framework was utilized for the thematic analysis to identify themes, i.e. patterns in the data that are important. The interviews were audio-recorded with the consent of the participant and transcribed. After initial transcription of the interview data, it was reviewed several times for a general understanding. Relevant phrases were identified and grouped together according to the corresponding questions. The identified phrases were further analysed for patterns in relation to the research question by categorising them against priori headers (Saunders, Lewis, and Thornhill 2016). The priori headers are basically the main challenges identified from the systematic literature review. A latent thematic analysis was conducted to examine underlying ideas, conceptualisations and ideologies with the aim to test the responses in the context of this research and deduce themes.

4. Findings

The analysis from the interview findings was summarized into four broad themes of Measurement, Materiality, Engagement and Resiliency. Analysing responses from the interviews, there evidently is a need for tackling emissions differently for upstream and downstream categories of Scope 3.

Measurement: To detangle the complications for quantification of Scope 3 with the multiple frameworks, standards and industry average emission factors, there is a need for industry wide standardisation for efficient reporting. Building a digital

core by pulling data, AI across the value chain to create an “intelligent operation” will enable end-to-end supply chain visibility which is currently inadequate believe all respondents. Also missing is measuring against a baseline (WRI, n.d).

Materiality: There is also a current lack of awareness within the organizations regarding their direct and indirect supply chain emissions which acts as a barrier to managing those emissions. As the famous adage goes “What gets measured gets managed” but if it is out of sight, it might as well be out of mind. When companies take ownership of their supply chain emissions – both upstream and downstream – only then the importance of Materiality Assessments (MA) is realized. Currently entrusted to Third Party consultants, its success or failure depend largely on engaging the right stakeholders. Conflicting business priorities are often one of the major barriers for accurate material Scope 3 emissions accounting as shareholders don’t want to jeopardise their pay checks in the name of sustainability.

“For private companies it’s much more than the customer push or even maybe an internal employee push. It’s rare to see you know things to just happen organically from inside because usually the primary pressure is always going to be revenue and profit.”

- Director of Climate and Energy - FMCG company

Engagement: A major part of Scope 3 comes from consumer usage for FMCG companies. Therefore appealing to young environmentally conscious customer segments, by making sustainability “trendy” could be an important step towards Scope 3 reduction. Engaging the internal workforce by enabling them to comprehend measuring and reporting Scope 3 emissions data is important. Also, creating a sustainability strategy on paper is not suffice. It is as one of the Senior Consultants pointed out should be aligned to the Company vision. Proper supplementation is when the right stakeholders are engaged and onboard. The same view was reflected by the Executive VP of Supply Chain Management.

“Companies are really good at putting a strategy as sustainable sustainability strategy on paper driven by customer or consumer requirements or Carbon accounting legislation. Then the execution is actually most of the time, driven by a company’s Own purpose.”

- Executive Vice President SCM

As John (2020) points out , changing working patterns rather than increased spending is key for FMCG businesses which run on high volumes and low margins, with less room for manoeuvring in cost terms than in other sectors. From latent thematic analysis a recurring theme for Scope 3 reduction was circular economy solutions. Companies need to take “Extended Producer responsibility by i) building correct infrastructure for reverse supply chains as well as ii) invest in Research and Development to extend product lifecycle - both important considerations for Scope 3 reductions in downstream supply chains for companies. Similarly, nearshoring the supply chain, at least even in part can offer potential impact on Scope 3 emission in the upstream supply chains of FMCG companies.

Resiliency: Supply chain digital integration can serve as the backbone of resilience with connected value chains for real time information about disruptions, buying, selling and moving goods throughout the value chain. So that all of the suppliers are connected to company and company connected to all your customers. The same connectivity allows us to also measure carbon in a much more accurate way. Resilience is the crucial missing link that can offer potential impact on Scope 3 reduction. For FMCGs rather than going for volume, narrowing scope could be an alternate thought of “not dancing at every wedding”. However, trade-offs need to be evaluated carefully for each case to arrive at a win-win for companies.

“You need this perfect tension of resilience and sustainability that work together. And finding that balance, I think is the work companies need to do.”

- Director of Climate and Energy -FMCG company

5. Recommendations and Conclusion

5.1 Framework for overcoming challenges

Based on the thematic analysis a conceptual framework (cf Figure 2) is proposed hereafter for tackling the barriers to Scope 3 emission reduction for companies.

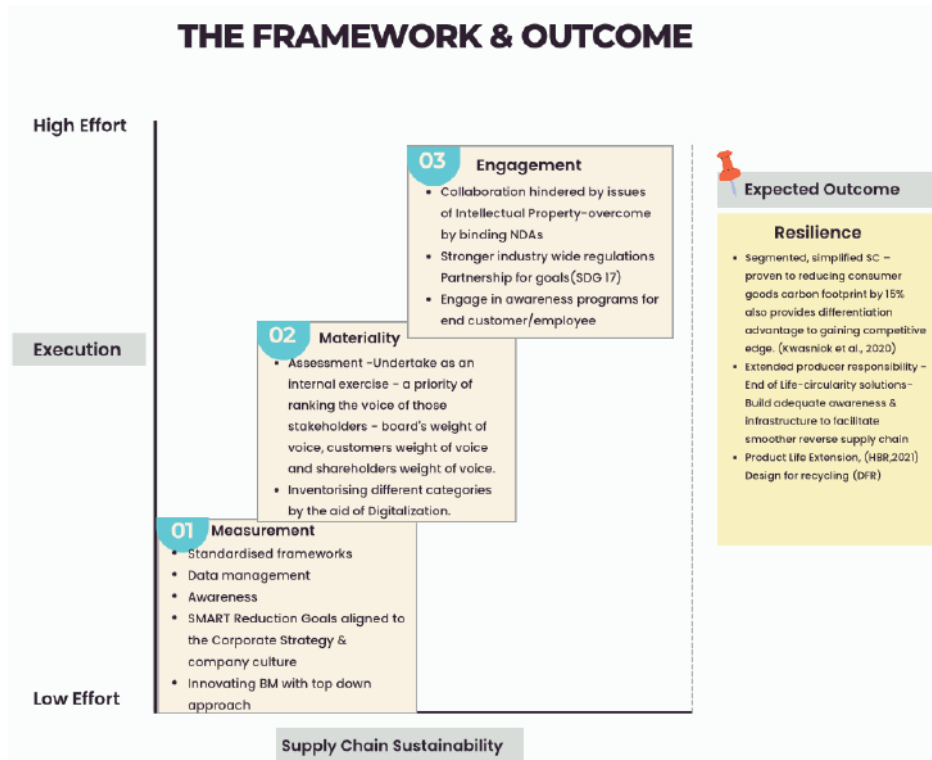


Figure 2: The Conceptual Strategy; Source: Built from Interview Responses and thematic Analysis

A 2X2 matrix is devised as per effort that needs to be invested to overcome barriers for sustainable supply chain practices with Resilience as an Outcome. There are overlaps between the boxes as they cannot be done in silos. Segmenting and simplifying supply chains can result in decreasing carbon footprint of products sometimes by 15% (Kwasniok et al., 2020).

5.2. Conclusion

The fast-moving, fragmented, consumer-centric world demands future supply chains to be more dynamic - to predict, prepare, and respond to rapidly evolving demand amidst changing product and channel mix unlike traditional supply chains sought focused on achieving stability and minimized costs (Henrich et al., 2022). The urgent need to manage and mitigate Scope 3 emissions in supply chains should be in line with the company vision. Having a strategy on paper is a good first step but taking actual steps for implementation is crucial. With increasing regulations around the globe, companies stand to gain competitive edge by engaging in Scope 3 accounting. Not only that, companies need to take 'Extended Producer Responsibility' not just make billions of dollars off of goods that are manufactured offshore also build infrastructure to ensure safe disposal of used goods, align suppliers to their sustainability goals and build more awareness to ensure that they are really taking responsibility for those actions and manufacturing activities.

As this is only a conceptual framework, it holds potential for future research to determine the impact on the bottom line for companies.

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DEVELOPMENT OF DIGITAL CUSTOMER EXPERIENCE IN LOGISTICS SERVICE INDUSTRY

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Introduction

Due to changing business environment and trends affecting logistics, companies are facing continuous need to revise their logistics operations. Digitalization and automation have changed the know-how needed in logistics and are estimated to continue to shape the demand for logistics expertise (Laitinen, 2019; DHL Global, 2023). The rapid pace of change in digitalization requires companies to learn new things, adapt to changes and develop digital customer experience using new technologies (Gerdt, 2018). Digitalization opens the road to a digital customer journey, and well-functioning digital solutions are expected to make the business effective, ensure the customer satisfaction and to grow the market share (Haveri, 2018). Creating superior customer experience and customer orientation are two of the central objectives in today's business environment. Customers seek to engage with service brands and cooperate with service organizations that enable superior experiences (Lemon and Verhoef, 2016). Customer experience is evoked each point of contact at which the customer interacts with the company, its product, its service, its communication, and for example advertising (Grewal et al., 2009).

Customer experience and behavior are viewed as two of the most important research issues for researchers and operating challenges for companies (Leinonen, 2018). The purpose of this paper is to study the digital customer experience in the context of logistics service industry. The aim is to describe the elements of successful digital customer experience, and the views of the future development of digital tools and services in logistics. The challenges and barriers to reach the desired future of digitalization and digital services are presented, as well as the process of analysis used in this study to explore the digital customer experience. In this study, we aim to answer the following research questions in the context of logistics service industry: 1) What are the elements of successful digital customer experience? 2) What is the desired direction and future of digital service development from the customer point of view? and 3) What are the challenges, barriers, and other affecting views to reach the desired future of digital services?

Literature review

Digital customer experience

Customer focus and superior customer experience are virtues that many companies seek. To increase customer's loyalty and advocacy, companies must consider constantly positive and unique customer experience. (Weber and Chatzopoulos, 2019) Customer experience consists of individual contacts between the company and the customer at distinct points in the experience, called touchpoints (Homburg et al., 2017; Schmitt, 2003). Experience is always a subjective experience, and it refers to the personal perceptions. Customer experience can appear in many ways, such as physical, mental, emotional, and virtual experience (Schmitt, 1999). Pine and Gilmore (1999) emphasize that experiences occur when customers are involved in such a way that those experiences provide permanent and unforgettable impressions. Customer experience is multidimensional and holistic in nature. It encompasses customer's cognitive, emotional, behavioral, social, sensorial and value responses to the organization's offerings (Bolton et al., 2018; Lemon and Verhoef, 2016; Verhoef et al., 2009).

Development of digitalization have changed the customer journey from a regular customer experience into a digital one where several touchpoints are supported by digital tools (Weber and Chatzopoulos, 2019). Digital customer experience takes place between the customer and the company directly or indirectly through digital channels (Folcan, 2022). In other words, digital customer experience refers to all those touchpoints where the customer and company meet online (Trustmary, 2022). Sihalahi and Rufaidah (2018) state that digital customer experience consists of the factors like digital service experience, digital image experience, digital touchpoint experience and digital broadband experience. Rose et al. (2011) identifies nine cognitive and affective factors that correlate with digital customer experience: data processing, ease of use, utility, benefits, control, skills, trust, risks, and enjoyment. Gerdt (2018) sums up the development of a digital customer

experience in four different areas: personalized service, user-friendliness, real-time and technological environment. Filenius (2015) highlights that user experience is an individual experience because every customer experiences service differently. Companies often strive to make the digital service appeal to a larger number of customers, and the service is developed based on general customer feedback (Filenius, 2015).

The challenge is how to create and manage unique customer experiences. Customer experience management (CEM) has been introduced to be one of the solution concepts, as well as to focus on yielding total customer experience (Weber and Chatzopoulos, 2019; Mascarenhas et al. 2006). The field of CEM is a relatively new area for future research (Lemon and Verhoef, 2016). CEM tries to ensure a positive experience for customers by focusing on convenience, value, quality and perfect customer experience in the markets the firm serves (Verhoef et al., 2009). The processes for creating the total customer experience have been analyzed through, for example, the value chain and customer journey approaches (Leinonen, 2018). Companies must optimize whole customer experience by focusing on both digital and physical channels, so called multichannel environment, or even more effective, provision of seamless experiences across all channels known as the omnichannel approach (Weber and Chatzopoulos, 2019). Filenius (2015) emphasizes that developing a digital customer experience does not always require large investments. It is often enough to do the small details correctly, to think about the customer's needs, and to carry out the needed measures to the end. For example, Haveri (2018) found in her research that one of the biggest reasons for not using the digital solutions among customers, was not knowing about the solutions.

All in all, customers appreciate the ease of use of the service, and user experience has become one of the most significant competitive factors for the companies (Filenius, 2015). Customers seek to interact with service organizations that enable superior experiences (Lemon and Verhoef, 2016). In the future, the development of the digital customer experience will be guided using artificial intelligence, increasing self-service, utilization of data, cloud technologies, automations and new business applications and user interfaces. The pace of change in the digital environment is fast, and investment in technology will inevitably increase in the future (Gerdt, 2018).

The Futures Triangle

The Futures Triangle is the analytical framework, which helps to establish a big-picture view of changes and recognise desired futures and barriers to change. It maps today's views of the future through three dimensions: the push of the present, the weight of the past and the pull of the future. The push of the present and the weight of the past are based on current information, whereas the pull of the future is insightful and includes different images, dreams, and wishes of the future, which pull us forward. The pushes of the present are drivers and trends that are changing the future. The weights are the barriers to the change we wish to see, such as continuities, belief systems, world views and obstacles to change (Inayatullah, 2008; Sitra, 2023). The Futures Triangle is presented in Figure 1.

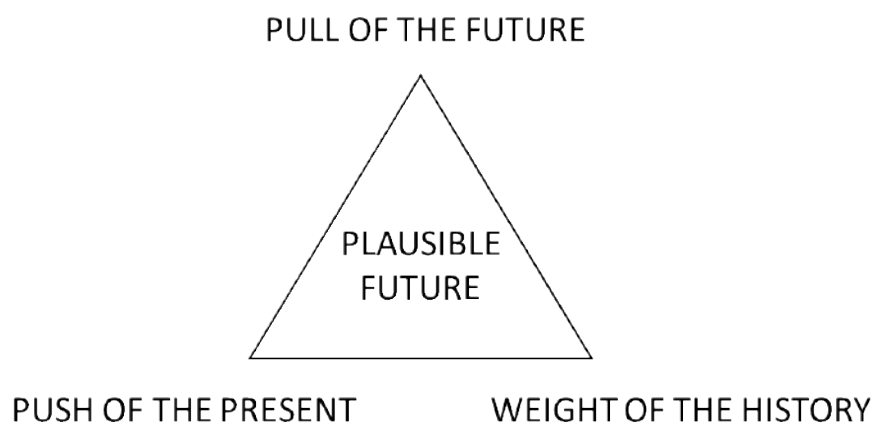


Figure 1: The Futures Triangle (Inayatullah, 2008).

Methods and process of the workshop

This paper is based on qualitative research methods, and it is by its nature a case study, in the form of four expert workshops (organized in Finland, in March 2023) and literature review. Through the literature review, we studied the elements of successful digital customer experience and how customer experience has changed through digitalization. The aim of the workshops was to discuss and reflect with logistics experts on digital services and the customer experience related to them. The approach in the workshops were future oriented, and we used the futures triangle as a method and framework. The triangle is especially useful for identifying the factors affecting the future of a specific chosen theme. In this context, the futures triangle aided in ascertaining the current state of the digital services, the development measures to the desired future and the challenges and barriers to change. The results of the workshops were analysed using qualitative content analysis.

The participants of the workshops were primarily logistics managers and directors of trade and industrial companies. Each participant had their own experiences and perceptions of digital customer experience related to their business, which allowed for an interactive and fruitful discussion between the participants. During the workshop, we discussed the three dimensions of futures triangle the current state of digital services and customer experience, the desired future of digital services and the bottlenecks to reach this desired future. We had reserved one hour for each workshop, and the futures triangle framework was on the table in paper form allowing facilitators and participants to write down all discussed thoughts using Post-it® notes. We started the workshop by considering what constitutes a successful digital customer experience. In the first step, the participants used five minutes to think and write their thoughts on Post-it® notes. This task also served as a warm-up task. After this, we discussed the issue together and finalized the notes. This discussion was followed with the question on how the logistics service provider's current digital tools and services work and serve the participants as customers. Then we moved to discuss and visualize the desired future of digital services. The themes like needs, desires, new tools and services, interfaces, ecosystems, operation models, images of futures were discussed in this aspect. Finally, we discussed the challenges, barriers, and other views of the participants in achieving the desired future. During discussion, if necessary, we also moved from one dimension to another enabling innovative and open conversation. The framework used in the workshops is presented in Figure 2.

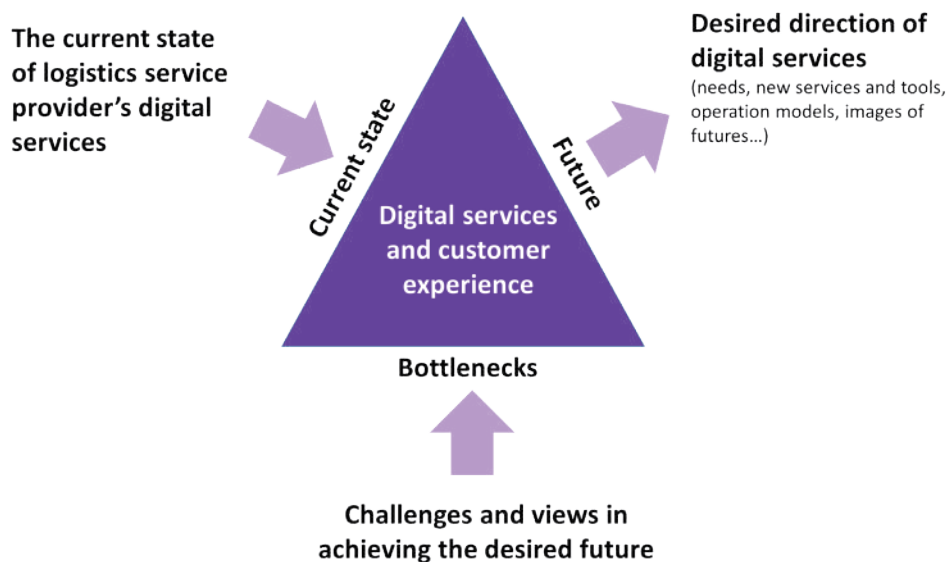


Figure 2: The futures triangle framework used in the workshops.

Results

Participants of the workshops mentioned several elements that make up a successful digital customer experience. We recognized the following nine themes: accessibility, clarity, customer-specific service, speed of service, data security, technical support, information-related matters, the emergence of the wow-effect and professionally managed changes.

The logistics experts especially valued easiness, usability, clarity, and real time of digital services. Digital tools, websites and instructions should be clear and understandable. Speed of service, short processes and data security were also highlighted in the discussions. According to the experts, a successful digital customer experience also requires the availability of real time technical support. Information should be correct and reliable, and the first encounter with the digital tool should be positive. One participant expressed that “the digital customer experience should be at least as good as the face-to-face customer experience.” The experts also wished as few updates as possible for the digital tools.

The question “How the logistics service provider’s current digital tools and services work and serve the participants as customers?” also sparked a lengthy discussion. Most of the experts said that there is enough information available about digital tools. However, the discussions also highlighted a desire for more active contact and communication, more marketing of the digital services available and more user training. Participants also said that e-mails are still widely used in communication and for transactions, since it is easy to use and familiar. Related to tracking, some participants mentioned about the unknown location of transported goods, data on not being up-to-date regarding location of ships and road transport. Additionally, they also emphasized that the most relevant thing is to know when the orders will be delivered. There was a positive discussion related to data availability (e.g., Sea Explorer was mentioned as an example) and that you can get reports from one place and that tools works fine. One challenging aspect from the customer point of view is that there are too many tools, because each company has its own. There is a need to manage and learn how to use different systems and tools. This also leads different data and separate reports. One participant also said that there is still a lot of manual work to be done for the flow of information.

We also discussed about the desired future of digital services. First, the participants agreed that the big picture shows that digitalization will increase, digital world will be more initiative-taking, and logistics will be more discreet and seamless in future. One participant mentioned that their desired image of future is, “You do not have to do anything by yourself, digitalization takes care of the processes”. Another participant emphasized that, “Digitality is not an intrinsic value, but a tool.” The participants highlighted that digital tools and services should be developed so that processes, systems and people are in balance. They agreed that the traceability and predictability in supply chains are the foremost things in the future development of digitalization and digital services. Situational awareness of the entire supply chain is by far the most vital information needed, e.g., the real time information about the delivery locations and forecast of the movement of goods. In the future, there will also be an interest in CO2 emission data.

In future, the participants would also like to have more information about decisions taken and unexpected situations, e.g., why a container is in the Hamburg container yard or why a ship changes its route. This kind of information is especially needed in the field of road and sea transportation. To develop traceability in future, the trackers should be in containers and trailers (attached to the load). Participants also discussed that artificial intelligence produces and forecasts better data, but this data should be made available for use. For developing digital services, the logistics service providers should further develop the dialogue with customers, provide possibilities to obtain customer feedback, and find out what information their customers need to develop personalized services for them. This requires not only close cooperation between logistics service providers and their customers, but also time and human resources from both sides. The participants believed that, in future, data will be integrated from different systems on the same platform and also sent to the customer’s systems. However, there was also a voice for the possibility to have a personal service by phone and email also in the future.

The third futures triangle dimension was the bottlenecks. The experts were asked to discuss about the bottlenecks, challenges and other views they saw that affect the process to reach the desired future. Based on the discussion, we formed the following ten themes: management of digital services, psychological point of view and fears, operational environment, need and sharing of information, regulations, systems and system-centricity, personnel and time resources, invests, communication culture, and planning and developing the digitalization. Related to management of digital services, the experts raised that inconvenient and slow phone service, and especially the problematic robot chats, is an issue. Typically, a robot chat does not help a customer. Due to this, the customer has to call a customer service personnel. This is wastage of the customer’s precious time. The experts were also worried about how the users can follow the development of services, as well manage and be aware of several different services and service systems. From a psychological point of view, it is vital that digital services and tools are attractive and easy for users to use, otherwise the digital customer experience will not be successful. The experts also raised several fears, which might be barriers for the desired future and future development. One of the fears was that the digital information will be somehow misused. Another fear was that they can lose their competitive advantage. Fear of losing customers, and that digitalization will replace the personal service were also mentioned.

Not only is the operational environment of logistics complex to function, but also logistics is a very traditional and a conservative field of business. This influences of course on future development. The experts also discussed how today's insecurity and uncertainty about the world situation and crises may affect the development of digitalization. Because of this, the cooperation between the companies might decrease, and companies will "snuggle" and just concentrate on surviving. The need for the information is and will become increasingly important. The customers will want more real-time information and getting forecasted data will also be important. The question is: which information is relevant, and how to define and find the most appropriate information in decision-making. One expert mentioned the metaphor that "we should see the forest for the trees". Related to information issues, in the future, the reporting will generally increase. One of the challenges is that companies will not see the value of sharing information and feel, that it means extra work for companies. The problems of sharing information was seen as a barrier for future development by the experts.

Various regulations will increase, which will, therefore, accelerate and direct development, for example, GDPR (General Data Protection Regulation) was mentioned as an example. One worry, highlighted in the workshops, was whether system users will be taken into account when developing the systems. The fear is that systems will determine, not the people. For example, the websites should be in plain language. A challenge related to systems, is that each service provider has their own systems, and they are opposed to change it, "keep the yarns in their hands". The experts also discussed about the personnel and time resources and their sufficiency, for example the marketing resources. Digital investments are usually expensive, and to make a decision to invest can be very challenging and tricky. All in all, experts saw the digital development as a positive aspect and planning of course should be future oriented. Development of digitalization in road freight transport, was mentioned as a specific example. Development is evolving. Results of the workshops are summarized in Table 1.

Current state		Future	Bottlenecks
Elements of successful digital customer experience • Accessibility • Clarity • Customer-specific service • Speed of service • Data security • Technical support • Information-related matters • Emergence of the wow effect • Professionally managed changes	Observations on digital services • Information about the tools • Marketing the tools • User training • Active contact and communication from the logistics service provider • Information about the deliveries • Real time tracking • Well-functioning digital tools • Reports from one place	Desired future of digital services • Digital world will be initiative taking • Discreet and seamless logistics • Digitalization takes care of all the processes • Processes, systems and people in balanced • Integrated digital systems • Transparency, traceability and predictability of supply chains • CO₂ emissions data • Personalized services & Traditional personal service • Active communication	Challenges and views achieving the desired future • Management of digital services • Psychological point of view and fears • Operational environment • Need and sharing of information • New regulations • System-centricity • Lack of personnel and time resources • Invests • Communication culture • Planning and developing digitalization

Table 1: The results of the workshops in a nutshell.

Discussion and conclusions

This paper studied the digital customer experience in logistics service industry. The paper sought to answer three research questions. The first research question was: "What are the elements of successful digital customer experience?" In this study, the following nine elements were found: accessibility, clarity, customer-specific service, speed of service, data security, technical support, information-related matters, emergence of the wow-effect and professionally managed changes. In a nutshell, digital customer experience will be successful, if digital services are easy and fast to use, information is in real-time and technical support is available. The logistics' customers would value digital customer experience, if it is at least as good as face-to-face customer experience. Moreover, the customers appreciate information about the digital tools that are available, marketing the tools, active contact and communication from the logistics service providers, information about the delivery times and dates, real time tracking of the deliveries, digital tools that work and access to all reports in one place. Customers would also value if there would be one common tool used across all the companies. The second research question examined in this study was: "What is the desired direction and future of digital service development from the

customer point of view?" Several visions for the future were highlighted. Digital world will be initiative-taking, logistics will be more discreet and seamless, and digitalization will take care of the processes without unnecessary manual work. Digital tools would be developed by taking processes, systems, and people into account. Digital systems will be integrated. Supply chains are transparent, traceable and predictability. CO2 emissions data is in focus. Services are personalized to an appropriate extent and dialogue with the customer is active and personal service will stay. Lastly, this study sought the answer to the third question: "What are the challenges, barriers, and other affecting views to reach the desired future of digital services?" Based on the discussions the different issues were emphasized: management of digital services, psychological point of view and fears, the nature of operational environment, increasing need and sharing of information, new regulations, system-centricity, lack of personnel and time resources, expensive and challenging invests, communication culture, and planning and developing the digitalization.

As a conclusion, the logistics customers value especially easiness, usability, and real time of digital services. The traceability and predictability in supply chains were seen most foremost things in future development of digitalization. The results highlight the importance of cooperation between customers and logistics service providers when developing future digital services. The experts participating in the workshops, assessed the framework of futures triangle as a suitable method to study digitalization and customer experience. This study deepens the information and understanding about the customer experience of the digital services in logistics industry in the light of sustainability and future development. In addition, the use of futures triangle method gives a new approach to investigate the digital customer experiences. For the companies, this study illustrates the elements of digital customer experience and increases companies' understanding of customer needs for the development of the digital tools and services. This information can be used to support strategic decisions and further develop the customer relationships and experiences. The method used in the workshops is also usable for the companies. In future, it would be interesting to study and validate these results with follow up workshops with the logistics service providers. The more international context and comparison between different countries would be also valuable to study to understand more deeply the nature of digital customer experience.

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AN EXPLORATION OF ATTITUDES AND PERCEPTIONS OF FREIGHT OPERATORS IN IRELAND TOWARD ADOPTING BIOMETHANE FUELLED HEAVY GOODS VEHICLES

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1. Introduction

Road transport accounts for 75% of all transport related emissions. Within road transport, road freight contributes around 40% of the emissions, posing significant obstacles to achieving decarbonisation goals (deSaxe et al., 2023). Cleaner energy fuel vehicles (CEFVs), considered as a silver bullet for decarbonising freight transport, have received increasing attention from policy makers and industry practitioners (Mohammed et al., 2020; ITF, 2021). CEFVs are vehicles that run on fuels that produce lower carbon emissions compared to petrol or diesel. These include hydrogen, electric, solar-powered, ethanol, and biodiesel vehicles (Li et al., 2019; Mohammed et al., 2020). Among the various CEFs, several studies and trials have demonstrated that biomethane fuelled heavy goods vehicles (HGVs) have lower carbon emissions and costs compared to their diesel counterparts (e.g., Madhusudhanan et al. 2020). Ammenber (2020) and Osman et al. (2023) argue that depending on substrate, biomethane can be the best solution for fossil-free logistics as it is already available in contrast to other solutions. Additionally, in case of disrupted supply of biomethane, natural gas can be used, allowing for alternative refuelling options that are not available for electric HGVs. However, the uptake rate of CEFs, including biomethane, by HGV freight operators in Europe remains low, with only 0.6% of all new registered HGVs in the EU running on CEFs (ACEA, 2023). Thus, this study aims to develop a freight operators' technology adoption framework for biomethane technology to support decarbonisation of road freight transport by addressing the following research objectives:

1. To Evaluate attitudes and antecedents toward adoption of vehicle technology for biomethane systems.
2. To Identify drivers, barriers, and potential policy support mechanisms.
3. To Develop a freight operators' technology adoption framework for biomethane technology to support decarbonisation.

This paper presents the findings of the first phase of this research project with a focus on freight operators in Ireland; where HGVs are responsible for 20% of all road transport related emissions, and with over 99% of HGVs still running on diesel (DfT, 2022). Notwithstanding such a challenge, the Irish government aims to reduce transport-related emissions by 42-50% by 2030, with a focus on alternative and CEF for all vehicles.

2. Literature review

2.1 Technology adoption frameworks

Technologies play a pivotal role in decarbonising logistics operations. Mathauser and Hoffman (2019) distinguish between two types of logistics technologies, namely: hardware and software. From automation and robotics to the recent rise of blockchain and AI, many disruptive technologies have emerged, with the promise to drive the logistics industry to a greener future (Nand et al., 2023). Regarding road freight transport, the decarbonisation endeavours pledged by multiple countries following the European Green Deal impelled the phase-out date for fossil fuel HGVs (de Saxe et al., 2023), which forced the road haulage industry to make tough investment decisions to upgrade their logistics hardware and software technologies.

The Biomethane (BM)-HGV, as a hardware technology, among other CEFVs, is considered a currently available alternative option for hauliers to uptake and decarbonise their logistics operations, thanks to its viable cost (Madhusudhanan et al., 2020), drastic Tank-to-Wheel emission reductions (Prussi et al., 2021) and market availability (Ammenber, 2020; Osman et al., 2023). The adoption of BM-HGVs is mostly driven by the supply chain actors themselves rather than by

public stakeholders (Dahlgren and Ammendberg, 2022; Osman et al., 2023). Adoption enablers such as lower fuel costs, customers' environmental requirements, and organisational internal sustainability initiatives are identified among current BM-HGV users (Osman et al., 2023). However, the uptake of BM-HGVs remains low among HGV operators in Ireland and Europe. Barriers such as lack of refuelling infrastructure, lack of coordination between the deployment of BM-HGVs and refuelling infrastructure development, lack of knowledge and support from organisation, and switching costs are reported as common hindrances for the uptake (Takman and Andersson-Sköld, 2021; Prussi et al., 2021; Osman et al., 2023; Nand et al., 2023).

Mathauer and Hoffman (2019) argue that technology adoption is just one part of a larger process called the technology assimilation cycle. This cycle includes several stages: identifying and evaluating innovations before adoption, adopting the technology, and finally integrating it into the company's routines. Motivation and willingness are crucial in the early stages of acceptance, followed by access to and integration of the technology during adoption. Therefore, having a comprehensive technology adoption framework is essential for successfully navigating this transformative journey.

Several technology adoption frameworks have been utilised in logistics and transport research, namely: the Technology Acceptance Model (TAM), the Diffusion of Innovation Theory, the Technology-Organisation-Environment (TOE) Framework, and the Unified Theory of Acceptance and Use of Technology (UTAUT) among others (Xu and Lu 2020). However, compared to software technology, the adoption of hardware technology has not received sufficient attention in logistics research, particularly in the digitalisation era, where the "technologisation" of hardware solutions gradually turns them into high-tech products with disruptive potential for LSPs (Mathauser and Hoffman, 2019). As such, hardware technology should be included in technology adoption research.

2.2 The proposed augmented HOT-fit framework

To address this gap, this research utilises the Human, Organisation, and Technology-Fit (HOT-Fit) Framework which was originally developed to evaluate Healthcare Information Systems (Yusof et al. 2008) based on the DeLone and McLean's IS Success Model and the Information Technology (IT) organisation fit model for the health IS (Yadegaridehkordi et al. 2020). The framework prioritises three constructs and analyses the effect on net benefit and extracts the barriers and motivators. The advantage of this framework is its capability to assess organisational structure and organisational environment components, and their interplay with technology and the user (Erlirianto et al. 2015).

HOT-fit is a flexible framework that can be applied in various contexts, evaluation methods, stakeholders' perspectives, and different phases of systems' improvement lifecycle. It has been successfully used in multiple contexts such as cloud computing, medical records systems, and information quality management among others (Yusof et al. 2008, Ahmadi et al. 2015, Yadegaridehkordi et al. 2020). A review of the HOT-fit research studies shows that the constructs and dimensions of the framework have been adopted to facilitate the respective research context. For example, Nilashi et al. (2019) and Yadegaridehkordi et al. (2020) integrated HOT-Fit with TOE and added the construct of environment to the framework while they contextually adopted the dimensions of each construct.

Thus, to elicit and evaluate antecedents to biomethane adoption in a freight transport context, the original HOT-Fit framework was augmented by incorporating the dimension of 'Facilitating conditions' from UTAUT under the 'Human' construct. Additionally, the Legitimacy theory is proposed as a mechanism to align the attitudes of the firm with those of the external environment and inter-organisational partners (Suchman 1995). As such, Legitimacy theory bridges the constructs of 'Organisation' (HOT-fit) and the construct of 'Environment' (TOE). We assume the dimension of 'Structure' under the construct of 'Organisation' to represent the internal environment of the organisation in accordance with the Strategic Legitimacy Theory. The influence of the institutional environment as a motivator for the company to comply with societal norms is assessed by the construct of 'Environment' and the dimension of 'Institutional Environment'. (See Figure 1)

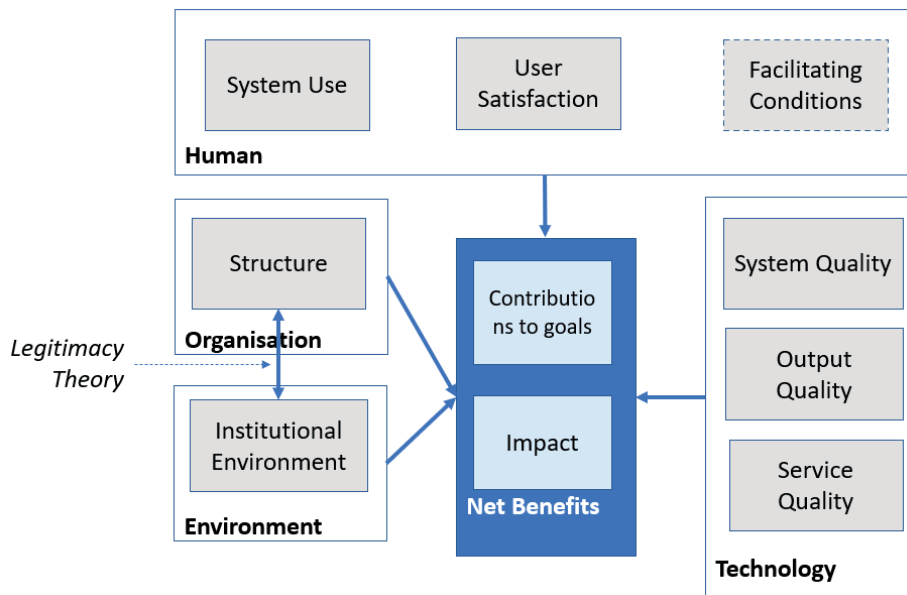


Figure 1: Adapted HOT-fit framework

3. Methodology

This ongoing research employs qualitative research methods as it investigates a dynamic and complex phenomenon in-depth and examines factors affecting the adoption decision of a relatively new technology within a dynamic environment and explores the experiences of early adopters (Golobic and Davis, 2012). A contextually adapted Human, Organisation, and Technology–Fit (HOT–Fit) Framework was applied to elicit and evaluate antecedents to biomethane adoption. Participants were recruited using a short online survey, which was disseminated through LinkedIn and emails to professional networks. Purposive sampling and snowball sampling methods were also utilised. To ensure the relevance of participants and enhance the robustness of the research design (Miles and Huberman, 1994) two selection criteria were set, dictated by the scope and research objectives of this study. As such, all participants need to work within the Irish haulage industry, and their companies must operate, have considered, or have decided against introducing BM-HGVs in their fleet. Table 1 presents the characteristics of the participants and companies that have been interviewed so far. The interviews lasted between 40 and 70 minutes. Three companies are early adopters of CNG/Biomethane fuelled HGVs, two are non-adopters and one is considering the adoption of such trucks. To cover all relevant topics while also allowing the interviewers to follow emerging threats, semi-structured interviews were used. An interview guide was developed and sent to participants before the interview to ensure their appropriateness in answering the questions and increase their awareness about the inquired topics (Miles and Huberman, 1994). Academics relevant to the topic reviewed the interview guide to ensure that questions were not leading and to avoid bias. All interviewees were asked for permission to be recorded. This allows the researchers to transcribe and analyse interviews using the original terms given by interviewees, and further avoid researcher bias more accurately.

	Position in the company	Decision on BM-HGVs	No of BM-HGVs	No of other CEF-HGVs	Total HGV Fleet	Company Type/ Sector
A	i) CNG Commercial Manager ii) Safety Manager	Adopters	17 (13.4%)	None	127	Haulier
B	Head of Transport	Adopters	230 (10%)	3	300	Wholesaler/Haulier
C	Co-Founder	Adopters	2 (100%)	None	2	Logistics Start-up
D	Sustainability Manager	Non-adopters	None	None	50	Haulier
E	Owner	Non-adopters	None	None	3	SME Haulier
F	Transport & Logistics Manager	Considering	None	None	2	Dairy Company

Table 1: Sample characteristics

4. Preliminary data Analysis & Discussion

To evaluate attitudes and antecedents toward adoption of BM-HGVs the steps of thematic analysis suggested by Braun and Clarke (2006) were followed. Initially, the interview transcripts were coded, similar codes were collated, and a set of determinants was developed. The identified determinants were checked by all researchers for consistency. The final determinants were then matched with the dimensions of each construct of the adapted HOT-fit framework. Each determinant can act either as a motivator for the adoption of BM-HGVs or as a barrier depending on the perception and experience of each company. The sections below present a narrative analysis structured around the constructs of the adapted HOT-fit framework.

4.1 Technology

The technology construct of the adapted HOT-fit framework consists of the dimensions of 'System Quality', 'Output Quality' and 'Service Quality', which examine the perception of performance of the bio-methane system in terms of reliability, convenience, ease of use, functionality, and other system metrics; the degree to which the biomethane system allows the driver to perform the job effectively and supports the quality of their work; and the extent to which internal and external technology service providers support the system users. From a 'System quality' dimension the drastic reduction of carbon emissions motivates the adoption of BM-HGVs. Company A argues "when we're driving biomethane, we're carbon neutral", a benefit they claim is not promoted sufficiently by relevant stakeholders. Company B claims: "We are looking at a 90% saving versus diesel looking at the carbon tonnage". Company F further supports this argument, "from a carbon footprint perspective I think biomethane has come out as the best option for us". Companies A, B and C further claim that by adopting BM-HGVs they are future proofing their businesses. It is also worth noticing that adopters and non-adopters agree the drastic carbon emissions savings are yielded only when the HGVs are filled with 100% Biomethane, which in Ireland became available in November 2022. Carbon savings from natural gas are only 20% less when compared to a diesel engine.

Another motivator reported by two of the adopters that can be classified under the 'System quality' dimension is the trustworthiness of the BM-HGVs over conventional diesel fuelled HGVs, with company C agreeing that the BM-HGVs appear to be very safe and that "the drivers were really happy with the spec of the vehicle in comparison to what they're used to with diesel". Furthermore, Companies B and F mentioned that the engines of BM-HGVs are quieter than conventional diesel HGVs. Company B says: "you don't have a noisy diesel engine, it's significantly quieter, and that's the feedback we are getting". This indicates that the system quality of the BM-HGVs has a positive influence in the 'System use' dimension of the Human construct. Company C further reports that "in terms of refuelling which is probably the main concern anyone would have understandably with CNG it's actually a very simple and safe process". Thus, ease of refuelling can be considered another motivator under 'System quality'. Noteworthy is that all the motivators that can be classified under 'System quality' refer to the quality of the truck rather than the Biomethane system that also comprises the biomethane production, dispense and refuelling network.

Moreover, range is another determinant related to the performance perception of quality of the trucks. Contradicting perceptions were reported for this determinant. Company E reports that there is a perception that BM-HGVs have a reduced range compared to diesel fuelled HGVs. Conversely Companies A, B and C report that the range of BM-HGVs is comparable to that of diesel HGVs, and much higher than other CEFVs alternatives such as Battery electric HGVs. Company D argues that HVO is a better alternative in terms of range. However, Company A retrofitted the tanks of their BM-HGVs and increased the range of the vehicle to be at par with diesel fuelled HGVs. Additionally, all companies reported that if refuelling infrastructure was in place throughout the country, then the range of the BM-HGVs would not be an issue. Indicative is the quote from Company C: "the range and these vehicles probably Max out 600 kilometres. So, while it's perfectly fine to get down to Kerry because you can refuel at Ballysimon, it's very challenging to get up to Donegal and back without refuelling. So, there is a limiting factor with the refuelling stations". As such the negative connotation of performance perception can be perceived as an inconvenience for long haul, which can be negated by retrofitting the vehicles or by the strategic development of refuelling infrastructure. Additionally, it can be indicated that lack of refuelling infrastructure negatively affected 'System Quality'. Operators would welcome policy support for the development of more Biomethane production and dispense facilities.

From the dimension of 'Output Quality' the interviewees reported only barriers for the adoption of BM-HGVs. All six interviewed companies mentioned the lack of refuelling infrastructure as the biggest barrier, a finding that is often reported in literature (see Takman and Andersson-Sköld, 2021; Prussi et al., 2021; Osman et al., 2023). They were critical of the delay of

the Irish gas network authority in building and commissioning the infrastructure that was planned in their strategy. Company B comments that they had to postpone the purchase of additional BM-HGVs because of this delay. The location of existing fuelling infrastructure acts as a determining factor as to where the trucks will be positioned. However, with only four public refuelling stations built in the country many locations do not have sufficient coverage. This has forced Company A to invest in private fuelling stations to facilitate their business. Company B is critical of the cost and space needed for the development of such infrastructure within private space particularly for small fleets. Company E further supports this particularly for small operators and adds that the lack of fuelling infrastructure is a barrier for SMEs and single truck operators located away from existing fuelling infrastructure.

The capital cost for the BM-HGVs is an adoption barrier that can be classified under the 'Output Quality' dimension. Company A mentions that these trucks cost 20k more than diesel trucks. The higher capital cost is mentioned also by the other companies. A subsidy grant was available in 2018 by the Irish gas network authority. Companies A and B availed of it, however, the scheme is no longer available. Company D comments that the lack of financial grants from the state is one of the reasons they decided against BM-HGVs. Companies C and E were critical of the subsidising schemes, with Company C mentioning that it might result in unintended outcomes, and Company E criticising inflated quotes due to such schemes. Company F further adds that the ease of switching diesel trucks to HVO is an additional barrier to the higher capital cost of BM-HGVs. However, it should be noted that the lower operational cost reported by adopters and the potential to future proof their business can counterbalance the initial cost.

In terms of the 'Service Quality' dimension, market readiness of BM-HGVs was one of the motivators that were reported by literature and the three adopters. Company A states "Gas is available today. It's in public stations and our private stations, and you can buy biomethane, or you can buy fossil gas". This outweighed other CEFVs in their decision-making process, as they report there are no guarantees as to when Hydrogen fuelled Electric HGVs will be made available. Company B states "it was always the ambition to use biomethane, in 2018 CNG became available, but we knew the roadmap was to get to biomethane". The BM-HGVs adopters also reported that these HGVs require less servicing. Company A claims "there is less servicing on them and there's no ad blue, that's significant". However, they are exploring the longevity of BM-HGVs in comparison to diesel engines. Company C claims that the service requirement of these HGVs is not a barrier. On the contrary, all adopters argue that OEMs offer end-to-end service packages that cover all the servicing needs of the HGVs. Company B states that the lease package covers all their servicing needs, they note however "it's more expensive but because we are adopting the new technology, we couldn't have something that didn't work". This quote extends to the only negative determinant reported by interviewees in terms of 'Service quality'. That is the cost of servicing. Company C explains that the duopolistic market of BM-HGVs in Ireland allows for OEMs to charge higher prices for servicing the HGVs.

4.2 Human

The human construct of the adapted HOT-fit framework comprises the dimensions of 'System Use', 'User Satisfaction' and 'Facilitating Conditions' to examine the perception of the drivers regarding the technology affordances of the BM-HGVs, the attitude and feedback from drivers who use BM-HGVs, the degree to which drivers believe to be in possession of the necessary resources, and knowledge to use BM-HGVs and the degree to which they believe that such trucks are compatible with other logistics equipment, respectively. Overall, the adopters of BM-HGVs argue that the feedback from drivers is pivotal in allowing them to consider the assimilation of these trucks in their fleets beyond pilot stages. Company B started with a pilot with two HGVs. The feedback from the drivers of this pilot was positive, and this influenced their decision to scale up the project.

From a 'System Use' dimension Company C argues that BM-HGVs are safer in comparison to diesel trucks in terms of refuelling. However, this view is not shared by the two non-adopters companies (D and E) who view the perceptions of users around safety issues associated with compressed gas as one of the barriers for adoption. Company B reported initial fears about the security of the operation were replaced by confidence upon training from trainers from countries that have a longer history in driving BM-HGVs. Company F argues "nearly all drivers would be confident, and competent to take on and maintain the truck [...] truck drivers would be able to switch relatively easily. And if there was some training, drivers would be able to make that adoption". This indicates that drivers' experience and training can act as two motivators under the dimension of 'Facilitating conditions' which in turn can positively influence 'System use' from a user perspective to overcome the barrier of safety perceptions of BM-HGVs. Another motivator from a 'Facilitating conditions' perspective reported by Company B is the deployment of BM-HGVs on planned routes along corridors with refuelling facilities. This has the potential

to overcome range anxiety and ease the barrier of lack of refuelling infrastructure in the 'Output Quality' of the Technology construct. A 'System Use' barrier mentioned by companies A and F is the difficulty to attract drivers, and that some drivers prefer diesel HGVs. However, the feedback of drivers who already use BM-HGVs from a 'User Satisfaction' dimension is that these trucks create more favourable driving conditions. This, Company B claims, improves the quality of the drivers' days, particularly in longer routes. Improving driving conditions for drivers could help overcome the barrier of attracting drivers "because driving experience has a direct correlation to driver retention" as stated by Company F. Additionally, companies B, C and F reported that their drivers have demonstrated willingness to adopt new technology, which acts as a further motivator for the companies to invest in these technologies.

4.3 Organisation

The Organisation construct of the adapted HOT-fit framework comprises of the dimension of 'Structure' which refers to the culture, characteristics, strategy, relationships with customers, and management style of the organisation to facilitate the adoption of biomethane and the mechanisms and systems put in place by the organisation to support the drivers. All participating companies reported that they are exploring initiatives that would reduce their environmental impact and improve their sustainability, albeit in varying degrees. The larger organisations from the sample appear to have well established sustainability strategies that cover their operations' spectrum. Companies A and B talked about sustainability initiatives implemented in other parts of their organisations. They noted that all the initiatives must be financially viable if they are to be greenlighted by the corporate office. Company E, the smaller one in the sample claims that "a common thing that I hear from small companies and sole traders in the haulage industry is that they're so just busy on the day-to-day operations that the long-term strategies like this, they just don't have the bandwidth to be thinking". Additionally, Company E claims that small operators face a scalability issue due to limited financial resources. They claim: "If you're operating with as little as 3% margin, you don't have that ability to scale like those guys with 300 trucks. So, in terms of your free capital then to invest in these more expensive methodologies like biomethane like E-Trucks, that's going to be prohibitive". Company F mentions fuel price volatility might act as a barrier for adoption, as they cannot afford to absorb this volatility due to the amount of fuel they consume and low profit margins. Thus, organisation size affects the likelihood to adopt green initiatives due to scalability issues and due to limited resources to pursue green strategies. Company C, understanding this limitation for SMEs, operates a consulting arm of the company to help such companies to improve their environmental impact. However, they are restricted on the amount of work of that nature they take on as their transport operations consume most of their resources. This indicates the need for an external organisation to assist with the sustainability journey of SMEs. The type and geography of their operations of Company D and the ban for CEFVs on ferries are restrictive factors for the adoption of BM-HGVs. They claim, "because we have our HQ in Dublin, our trucks still go either through England and the channel tunnel, or directly on the ferry to France [...] So if you change over your fleet, then you can't transport your goods". As such it can be argued that internal and external factors such as operational and geographical idiosyncrasies and transport related regulation can affect the decision of organisations towards the adoption of BM-HGVs. This indicates a two-way relationship between 'Structure' and 'Institutional Environment'.

4.4 Environment

The Environment construct of the adapted HOT-fit framework comprises of the dimension of 'Institutional Environment' which refers to regulations and policy support for the adoption of BM-HGVs, support from OEM for truck availability and servicing, pressures from customers and end-consumers for low/zero emissions transportation and support from infrastructure systems for refuelling. The interviewees commented that a more committing policy including a distinct set of incentives on National or EU level would drive the uptake of CEFVs among operators. Company E claims that in addition to the voice of the customers, change is driven by directives and laws. The decision of the three adopters appears to have been based on internal drivers and peer pressure from other companies in their group rather than external drivers. Company B claims that their investment in BM-HGVs was not driven by government policy, however, they are mindful of policies in other countries and decided to future proof their organisations in anticipation of policy. Company C agrees that once European directives transform into Irish law then more organisations will transition to CEFV. However, they mention that their investment in BM-HGVs allows them to give a better value proposition to their customers who are driven by their own sustainability agendas. Company A also agrees that there is a greater push from customers rather than government policy. As such similar to (Osman et al. 2023), it can be argued that the current Irish/European policy framework is not a driver for the adoption of BM-HGVs, rather companies pursue it as part of their environmental agenda or to respond to customers.

Gas price instability was reported as a barrier by adopters and non-adopters. Company B claims that in recent months gas price has stabilised and it allows them to yield benefits from lower operating costs of BM-HGVs. However, in recent years gas prices experienced volatility because of the socio-political turbulence in Europe. They claim, “In October [gas price] was 1.10 per kg versus diesel which was 1.40 less VAT and overnight it went to 3.50 [per kg] and that was after a lot of volatility before, [...] and then with the Ukrainian conflict and the day that Nord Stream 2 got blown up the price just went through the roof”. The price volatility affects the business case for BM-HGVs. They switched to diesel fuelled trucks until gas prices returned to normal levels. However, smaller operators such as Companies E and F do not have this flexibility in their fleet, as such the impact of the gas price instability is a bigger barrier for them. Furthermore, the lack of financial grants that was discussed earlier in Section 4.1 can be considered as a potential barrier from the ‘Institutional environment’ dimension.

4.5 Net Benefits

Net benefits refer to the extent to which the BM-HGVs and the entire system contributes to the success of individuals, groups, organisations, industries, and nations in meeting their predetermined objectives/targets, and to the impact on users and organisations from using BM-HGVs. All three adopters commented that BM-HGVs allow them to meet their sustainability goals due to the drastic reduction in carbon emissions they can achieve, particularly since they switched to pure Biomethane. Company C highlights that the benefits from switching to Biomethane for road transport extend beyond tailpipe emissions. They claim that the Anaerobic Digesters that are used to produce Biomethane can lead to improvements in animal slurry treatment and production of non-chemical fertilisers. Company F also mentions that if they switch to BM-HGVs they will also be able to reduce the environmental impact of their farms. In addition to carbon savings, Company A claims that the use of BM-HGVs gives them a discount on tolls on motorways, which is factored in the total cost of operations of the trucks.

The three adopters of the BM-HGVs commented on the potential to future-proof their business. Company A claims “You’re future-proofing your business using fossil gas or biomethane if the government or the European Union brings more rules, legislation, restrictions on diesel trucks in cities”. Company B claims that since BM-HGVs are considered zero emission vehicles, they will be ready for zero-emissions zones in case they are introduced in Ireland. Company C further comments that there is a sentiment that Biomethane is a bridging technology until other technologies become available, however, their analysis suggests that this is illusive for the HGV sector due to the energy requirements associated with long haulage. In addition to future proofing their business, Company A mentions that using BM-HGVs allows them to tender for large companies in specific industries and gives them a competitive edge in terms of scoring in the tender. Company B claims that they have not been able to quantify any competitive edge associated with the adoption of BM-HGVs from a customer’s point of view. However, they claim that they attract drivers over competitors who do not have such HGVs. Company E also claims that their customers have not enquired about clean transportation, “never and it’s a bit of a bone of contention because like in any business, it’s the voice of the customer drives the strategy”.

5. Concluding remarks

Since this is an ongoing research any concluding remarks are limited to the data analysed so far and do not represent the entire industry. From the analysis of the collected data a set of determinants was identified, these determinants can act either as motivators or as barriers. The majority of determinants identified confirm the literature on Biomethane as a transport fuel. However, some new determinants were identified relevant to geographical idiosyncrasies of the sample. Additionally, the analysis of the data allows for the constructs and dimensions of the adapted framework to be corroborated and for potential relationships to be identified. However, the current research covers a small sample from one country, as such any generalisations beyond the sample are not possible. Nevertheless, the findings of the present research are significant as they validate the selected research design and generate future research opportunities. Future research could expand the geographical coverage to include operators from different countries. It could also utilise a quantitative approach to examine the suggested relations between the constructs and dimensions of the adapted HOT-fit.

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A SYSTEMS THINKING ANALYSIS OF HUMAN AND MACHINE INTERACTIONS AND THEIR IMPACT ON WAREHOUSE AND ROAD FREIGHT OPERATIONS

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1. Introduction

Warehousing and road freight are indispensable to modern logistics and supply chain management. Warehouses serve as primary storage facilities for commodities, offering secure storage, inventory control, order processing, consolidation, and value-added services. They serve as intermediaries between the production and consumption stages, facilitating optimal distribution (Richards, 2022). Meanwhile, road freight is transporting commodities through trucks and other vehicles utilising road infrastructures. The benefits include flexibility, versatility, expedited transit times, tracking functionalities, and cost efficiency. The integration of warehousing and road freight facilitates the smooth transportation and storage of commodities, thereby enhancing supply chain management efficiency (Martin, 2018). Automation, artificial intelligence, and robotics have revolutionised the logistics and transportation industry, escalating in a new era of efficiency, speed, and accuracy.

Automated machinery and equipment can perform some parts of the task, but most will require human labour in the working system. People have the ability to solve issues and are cheap, quick, accurate, and flexible. Nevertheless, examining the complex relationships between human employees, intelligent machines, and the more significant operational systems that govern warehouse and road freight operations is necessary for this transformation. Sgarbossa et al. (2020) observed that system managerial decision-support planning models disregard or undervalue human factors. This oversight may negatively impact system performance, increasing operational time and expenses, decreasing productivity, and lowering work quality (Sobhani et al., 2015). The primary challenge management faces today revolve around effectively redesigning the work environment to facilitate collaboration between workers and machinery while motivating and engaging employees to carry out their tasks. Failure to address human factor issues can also lead to operator fatigue, pain, and injuries, which reduce performance and increase errors and job quality (Kolus et al., 2018). The productivity of warehouses heavily relies on the actions and contributions of the human workforce.

Hence, this research paper aims to develop a dynamic causal loop model that captures the interactions between humans and machines in warehouse and road freight operations using a system dynamics approach. This model aims to comprehensively understand the feedback relationships between human and machine inputs and their interactions within the warehousing work system. The model will encompass various aspects such as perceptual, cognitive, physical, and psychosocial factors. By constructing a qualitative causal loop model, we can identify the essential variables that must be included in the simulation model. Furthermore, this model will enable us to comprehend the complex cause-and-effect relationships among these variables in the analysis of the warehouse operation system.

2. Literature Review

Human-computer interactions entail a conversational or interactive exchange between individuals and computing systems. The present study introduces a theoretical model that draws upon established research in ergonomics (Grosse et al., 2015; Karwowski, 2005; Vijayakumar et al., 2022) to elucidate the dynamics of human-system interactions. The framework classifies human elements according to their influence on design and management decisions, affecting the interaction between humans and other system elements. Physical conditions, cognitive state, perceptual ability, and psychosocial work characteristics such as job control, work pressure, supervisor influence, satisfaction, and feedback are considered.

Meanwhile, Fruggiero et al. (2020) conducted a simulation study to investigate the impact of four physical, cognition, perception, and psychosocial factors on human behaviour during collaborative work with machines. Similarly, Chen et al. (2022) developed a simulation model that incorporates smart manufacturing techniques to account for the effects of human-machine interaction on inertia, capacity, and dependability, focusing on technical and cognitive factors.

Perceptual factors, including perceived workload and feedback, have been found to affect job satisfaction and quality of work (Yeow & Goomas, 2014). Furthermore, operators with good perceived workload reported higher worker satisfaction (well-being) and fewer mistakes (quality) (Vijayakumar et al., 2022). Implementing artificial intelligence (AI) in manual tasks can transform job roles and reduce physical limitations, but human error and safety implications must be considered (Dwivedi et al., 2021; Strauch, 2017). Warehouse personnel's expertise and operational knowledge are crucial to their performance and efficiency (Kumar et al., 2018), which sometimes outweigh their technological skills (Klump & Zijm, 2019; Mahroof, 2019). These knowledge and skills are acquired at a stable and maximal performance level (Golan et al., 2020). Multiple studies have explored the effect of emotions on job satisfaction. Positive emotions improve system efficacy, whereas negative emotions have the opposite effect Pekrun and Frese (1992). Human-machine interfaces can impact negatively by a lack of motivation to adapt to AI applications (Klump & Zijm, 2019; Lughofer et al., 2009).

This study addresses the research gap in understanding the complex dynamics of human and machine interactions in warehouse and road freight operations. A conceptual causal model is constructed utilising system dynamics methodology to achieve this objective. The causal loop model is presented as the qualitative phase of the model, which serves as the basis for the subsequent development of the quantitative phase through stock and flow diagrams. The conceptual model is valuable for understanding the problem before constructing a simulation model.

3. Methodology

The System Dynamics Approach

System dynamics (SD) is a robust modelling technique that can be applied to various problem-solving contexts to generate consistent patterns. Decision-makers can employ SD to simulate and evaluate prospective policies, reviewing the continual consequences of each policy before concluding a course of action. Systems thinking (ST) is a methodological approach that considers all variables that affect a system. It seeks to comprehend how these variables interact and how they can be interconnected more advantageously to produce improved results (Sternan, 2000). Both ST and SD are geared towards system comprehension and enhancement. Case studies and qualitative operations research (OR) studies help develop conceptual or mental models (Forrester, 1993).

The system's initial description is utilised to develop intricate models for evaluation. Qualitative and quantitative modelling techniques are employed to conceptualise and evaluate the system's interdependencies (Luna-Reyes & Andersen, 2003). The process of building a system dynamics model consists of five essential steps: (i) identifying and characterising the issue under study; (ii) formulating a dynamic hypothesis by mapping out the cause-and-effect relationships; (iii) constructing a mathematical model using a stock-and-flow diagram; and (v) developing alternative policy evaluations and scenarios. Figure 1 depicts a causal loop diagram depicting the feedback relationships between elements in closed-loop diagrams (CLDs). The fundamental causal mechanisms proposed to explain the reference mode of behaviour over time are depicted in causal loop diagrams.

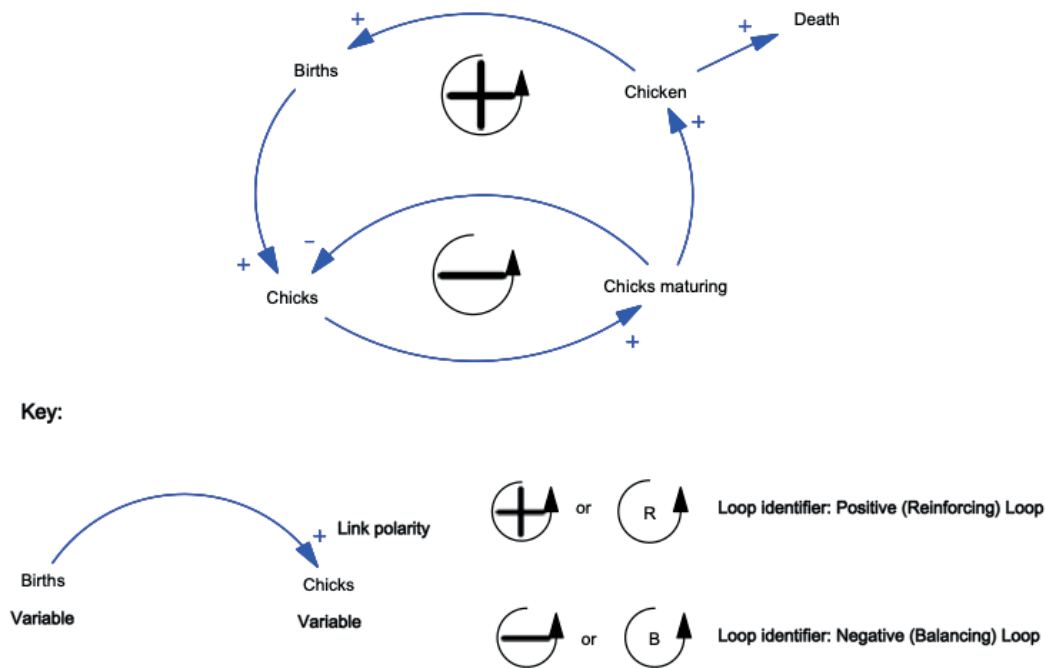


Figure 1: An illustrative example of a causal loop diagram

The causal relationships between variables are represented by arrows, with each arrow assigned a polarity (+ or -) that denotes the direction of change in the dependent variable when the independent variable changes. Positive and negative feedback loops are recognised as significant mechanisms in regulating systems. Positive feedback loops that contain an even or invalid quantity of negative connections exhibit instability and result in oscillatory behaviour, system growth, mutate, and eventual collapse. On the other hand, negative feedback loops that contain an odd quantity of negative links stabilise the system by diminishing the impact of the original variable via the affected variable. For instance, in the illustrative (Figure 1), an anticlockwise positive feedback loop between birth and chicken, alongside an anticlockwise negative feedback loop between chicks and chicks maturing.

The Delphi Technique

This study utilises an online Delphi expert survey to evaluate the CLD formulated through a comprehensive analysis of existing literature. According to Kaynak and Macaulay (1984), the Delphi methodology is a distinctive technique utilised to elicit and enhance group judgement. This approach is founded on the notion that a group of experts is more desirable than a single expert in situations where precise information is scarce. According to Hasson et al. (2000), Delphi studies involve proficient individuals in the particular field of interest under research. The Delphi method is a group facilitation technique that utilises a sequence of organised surveys to attain agreement among a panel of “experts.” These experts are often denoted as panellists, participants, or respondents and complete their responses anonymously. Several scholars have employed the outcomes of Delphi surveys to construct system dynamics models in diverse domains and sectors. For instance, (Harrison et al., 2022) utilised this approach to investigate transport-health matters, while (Tan et al., 2018) explored integrated coastal-zone management in sustainable tourism. Similarly, (Rees et al., 2017) and (Chen et al., 2012) employed Delphi surveys to examine transport systems and technology foresight in the ICT industry, respectively.

Identification of Experts

Experts participating in the survey should possess relevant experience, qualifications, and a comprehensive understanding of the research subject (Efimenko et al., 2019). Professional experts require a minimum of five years of industry experience, while academic experts should have a minimum of ten international publications to be considered (Rosa Pires da Cruz et al., 2013). Non-probability sampling methods, such as purposive sampling or criteria sampling, are commonly employed to select the sample of experts (Etikan & Bala, 2017), and this research also employs the same method.

Delphi Expert Survey

In Stage 1 of the Delphi expert survey, additional variables for the research query were formulated. Quantitative data, such as rankings and identification of significant links, were statistically analysed, whereas qualitative data from free-text responses were thematically classified using the NVivo software. The information gathered in Stage 1 was used to modify and expand the CLD by adding new connections and feedback mechanisms. In Stage 2, the Delphi method was used to validate the previously identified variable link relationships. The modified CLD was presented to the participants, who could propose additional modifications or accept it as an accurate representation of human and machine interaction in warehouse and road freight operations. If necessary, participants were asked to identify any incorrect or absent variables or relationships.

4. Results

Survey participants

The first stage of participants was contacted in January 2023, followed by the second stage in May 2023. The Stage 1 survey received only 10% of the response rate from the 50 experts invited to participate. The second stage survey was distributed to all five participants from Stage 1, with a response rate of 4 out of 5. It is important to note that all respondents in this stage are knowledgeable and experienced experts in the warehousing and road freight industry.

CLD Revisions

The modifications to the combined CLD were based on examining the information obtained from the Stage 1 survey. In Stage 2, the restructured CLD was presented to a panel of experts for their evaluation. All experts unanimously agreed that the restructured CLD effectively represents the subject system model, and they reached a consensus that no amendments are necessary for the causal links or variables within the studied system. The CLD underwent 20 amendments variables and developed 13 new causal links, presenting seven balancing loops and four reinforcing loops as shown in Figure 2.

The core functioning of the warehouse and road freight system is represented by a single balancing loop that focuses on the inbound process (B1). The human worker and machine input are represented by balancing loops (B2-B4) that balance the demand for work and its allocation. These loops focus on optimising the distribution of tasks between humans and machines based on the work requirements. Additionally, the system has reinforcing loops that relate to inventory shortages (R1) and order completion (R2). On the other hand, human-machine interaction can be influenced by mental, physical, psychosocial, and perceptual factors. However, the model primarily addresses three key factors through loops: physical impact (B5), mental impact (B6), and job satisfaction (R4). These additional loops were developed based on expert feedback analysis and relevant literature. Furthermore, the subsystem of human-machine interaction includes training schemes for workers (B7) and their overall well-being (R3). These aspects contribute to a comprehensive understanding of the human-machine interaction within the warehouse and road freight system.

Figure 2 visually represents the restructured CLD, with different coloured arrows denoting six sub-systems, including warehouse and road freight operations, inventory management, space resource, human resource, machine resource, and human-machine interaction factors. Meanwhile, the dashed links in the diagram constitute revised connections derived from the combined CLD literature and Stage 1 analysis. The notation (+/-) indicates whether the links are positive or negative. Additionally, the presence of <xx> signifies shadow variables that appear elsewhere in the CLD but have been repeated closer to the effect variable to enhance the diagram's visual clarity and readability.



The global demand for efficient supply chain services is anticipated to persistently rise in the coming years, driven by various variables, including labour shortages, cost minimisation, improved efficiency and productivity, technological progressions, safety and risk mitigation and many other factors. In order to optimise system performance and promote human well-being, it is imperative to comprehend the collaborative interactions between humans and machines within sociotechnical environments. In this research study, we have developed a Causal Loop Diagram (CLD) to provide readers with insights into these interactions within the context of warehousing and logistics transportation. It is important to note that the primary objective of this model is not to forecast future trends accurately but to gain a comprehensive understanding of the system's mechanisms by establishing cause-and-effect relationships.

This study's causal loop structures can serve as the basis for future stock and flow simulation model development. By incorporating stocks (accumulations) and flows (interactions) between different elements, these models will enable a more accurate representation of the SD. This stage of model development is crucial because it requires the formulation and estimation of parameter values and equations for each model element and identified link. In addition, examining leverage points within the model could provide insights on optimising warehouse resource utilisation and improving material flow, which can be applied practically to the warehouse and road freight sector. By identifying these leverage points, strategies and interventions can be devised to enhance the performance and effectiveness of the system as a whole. Overall, this research contributes to advancing knowledge and comprehension in the field, with practical implications for enhancing operational efficiency and decision-making processes in the warehousing and road freight domain.

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CURRENT SITUATION OF TURKISH LOGISTICS SECTOR IN ADAPTATION TO EUROPEAN GREEN DEAL

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Introduction

While the effects of climate change are more noticeable, the process of transitioning to a resource-efficient and green economy has become a global agenda for the purpose of combating climate change and foster sustainable development. Transport systems are associated with environmental impacts at the local and global level. Modes of transport, energy supply systems, and infrastructure affect emissions from transport. In the 1990s, with the spread of globalization, offshoring gained importance and maritime transport increased, leading to the growth of international trade. Longer distances by freight transport, because of offshoring, have increased emission rates. With COVID 19, the advantage of offshoring began to lose its appeal as supply chains became fragile and overall costs increased. Developed countries started to shift their production to countries close to them, which is characterized as nearshoring, so they tried to keep their own geographies cleaner and free from production-related environmental effects.

Türkiye began to attract direct investments from the EU countries in the 2000s, and has become an attractive alternative in terms of supply chain decisions as it is a safe and dynamic market. Customs Union (CU) is the major mechanism for economic issues between Türkiye and the EU. For 25 years, because the barriers/obstacles to trade between the two sides have not been completely removed, CU does not suit current needs for Türkiye. Also, additional restrictions within European Green Deal (EGD) might deteriorate the integrity of relationships, contrary to the CU spirit and Türkiye's accession process for EU membership. Although Türkiye is in the Customs Union, it is the only country that is not a member of the EU, which is confronted with the above-mentioned challenges. Despite its deep-rooted history and the significant trade volume between the two parties, these challenges make Türkiye's adaptation to the Green Deal Strategy more difficult.

EGD is the first policy strategy in the world (policy package) that has been put forward to overcome the concessions faced by both consumers and legal entities in sustainability steps. Since Türkiye's most important trade partner is the EU countries, it is essential for all sectors to transition to EGD and their active participation. Compliance with sustainable and smart mobility strategies and strategies within the scope of EGD are important agendas regarding the transport sector. Türkiye is an indispensable route country in terms of connecting the EU with other geographies (Central Asia-Middle East and others). In this study, European Green Deal is reviewed first within the context of international trade. Both the EU's and Türkiye's adaptation efforts to climate change are presented with international frameworks such as United Nations (UN) narrowing down to transport and freight mobility. Türkiye's Green Deal Action Plan is explained as its alignment strategy to EGD. Further, Türkiye-EU relations are discussed to outline Türkiye's unique status as the EU candidate country. Opportunities and threats to these relations on the Turkish side are analyzed from EGD perspective.

European Green Deal and Türkiye

Turkey has made great efforts to comply with the EGD, and the details of this effort are discussed in this section with a common reference to outputs of Intergovernmental Panel on Climate Change (IPCC).

United Nation's Intergovernmental Panel on Climate Change (IPCC) aspires to limit the global temperature rise caused by anthropogenic greenhouse gas emissions to less than 1.5 degrees Celsius in the long term compared to the pre-industrial era. Therefore, Paris Agreement was adopted in December 2015 as the legally binding international treaty on climate change during UN Climate Change Conference (COP21) in Paris (UNFCCC, 2023a)

Paris Agreement confirms that countries better contribute to mitigate climate change within the framework of the principle of "common but differentiated responsibilities and relative capabilities". Respectively, countries submit their national action plans, the so called NDCs (nationally determined contributions) every five years to UNFCCC Secretariat (e.g., 2020,

2025, 2030). Türkiye submitted its intended nationally determined contributions (INDC) in 2015 to UNFCCC before Paris Agreement. Türkiye did not implement Paris Agreement until October 2021, since it does not define “developed” and “developing” countries and further does not refer to UNFCCC annex lists (UNFCCC, 2023b).

The EU formally ratified Paris Climate Agreement in 2016. Within the context of European Green Deal, EU provided its updated NDC on December 17th, 2020 in order to reduce emissions by at least 55% by 2030 from 1990 levels (European Commission, 2014; UNFCCC, 2020). Annual greenhouse gas emissions of agriculture and industry declined within EU, whereas EU’s 2021 transport emissions are 18% higher than 1990 as 782 MtCO₂e. (European Environment Agency, 2023). ‘Fit for 55’ is the term used by the EU to indicate policy packages and initiatives in order to amend and bring legislation up-to-date for achieving climate objectives and its commitment under the Paris Agreement (European Council, 2023).

Türkiye’s 2030 greenhouse gas emissions were predicted as 1175 MtCO₂e according to Business-As-Usual (BAU) Scenario in its initial NDC from 2012 baseline of 440 MtCO₂e. Türkiye’s initial commitment was 929 MtCO₂e by 2030 as 21% reduction relating to BAU level. Türkiye’s official statement is that it contributed only to 0.7 percent of the global emissions since the industrial revolution. Türkiye first updated its NDC with 41% mitigation scenario instead with respect to BAU level, and submitted to United Nations on April 2023 with a commitment target of 695 MtCO₂e in 2030. Nevertheless, Türkiye officially undertakes its net zero greenhouse gas emissions target by 2053. Türkiye’s 2020 greenhouse gas emissions have been relatively lower with 524 MtCO₂e with respect to the estimate of 599 MtCO₂e in the initial mitigation scenario (UNFCCC, 2015; UNFCCC, 2023c).

Greenhouse Gas Emissions in Transport

EU managed to reduce greenhouse gas emissions from energy supply by 40% from 2005 to 902 MtCO₂e in 2021, and further improve to less than 700 MtCO₂e. Transport (both passenger and freight) emissions that were at the level of 848 MtCO₂e in 2005 are projected to decline to 631 MtCO₂e until 2030 with additional measures from 776 MtCO₂e in 2021 (European Environment Agency, 2022, pp. 21-25).

On the other hand, although Türkiye is founding member of OECD, rail infrastructure did not expand significantly after World War II, mainly as a side effect of Cold War, since Marshall Plan and other ongoing aids by United States promoted road transport instead of rail (UTIKAD, 2022). Consequently, efforts for rail infrastructure investment were unfortunately suppressed due to communist/leftist accusations over decades in Türkiye’s public opinion. Therefore, Türkiye’s freight volume increased from 2000 onwards in parallel to its economic and population growth which is reflected in Figure 2. GHG emissions in transport sector display a peak of 84.7 MtCO₂e in 2017, of which 76,6 MtCO₂e was due to road transport (TurkStat, April 2022).

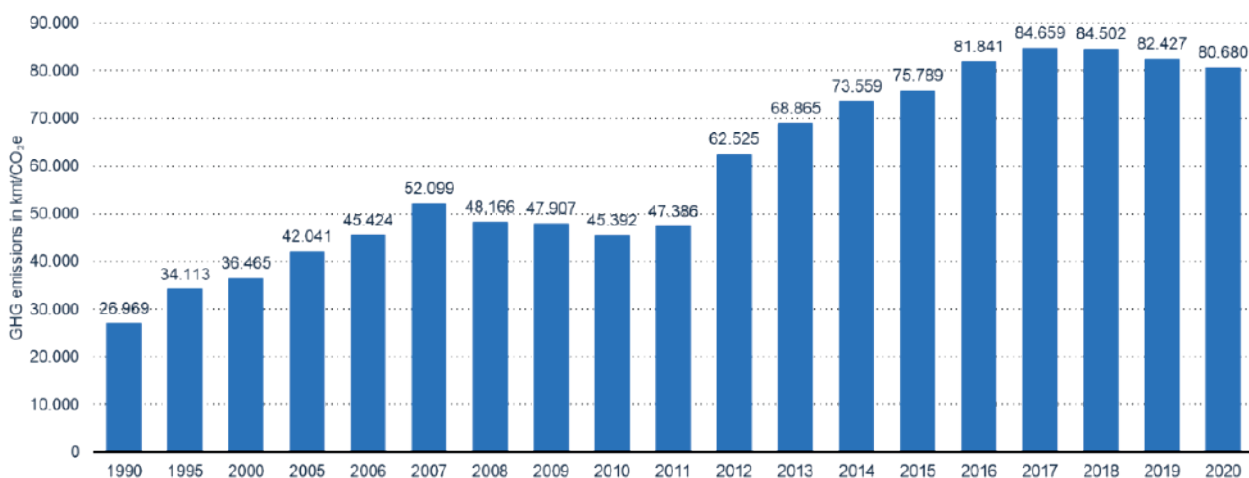


Figure 2: 1990 – 2020 Greenhouse Gas Emissions from Transport: Türkiye (Source: Statista, 2022)

Transport modes of Türkiye’s international trade are distributed as follow for the year 2021: maritime 63%, road 25.8%, air 9.7% and rail less than 1% (UTIKAD, 2021). Türkiye’s current level of population and potential economic development

is totally dissimilar to the EU countries. According to ITF Transport Outlook, Türkiye's freight volume by all inland modes of transportation reached a peak of 380.3 billion tonne-kilometers, an increase by around 11% from 2020, which was only 241.4 billion tonne-kilometers in 2010. Meanwhile Germany, which is Türkiye's leading trade partner with similar population, did almost not change its freight volume by all inland modes of transportation: 494.2 billion tonne-kilometers in 2021 with respect to 499 billion tonne-kilometers in 2010, where road and rail freight comprise 307.2 and 123.1 billion tonne-kilometers respectively (OECD, 2023). Türkiye should be entitled to participate in the Single European Railway Area (SERA) in order to increase the share of railways in Türkiye's international transport bringing it closer to Italy's 15% such that Shift2Rail Joint Understanding can achieve its vision to make railway customer-centered transport mode (Europe's Rail, 2019).

Türkiye's Green Deal Action Plan

Türkiye spends a significant effort to align with the European Green Deal. While public institutions publish policy documents on this issue, representatives of sectors and academia support efforts to raise awareness on the issue. For example, Türkiye's New Economy Program, covering the years 2021-2023, focuses on increasing production and exports in value-added products and sustainable growth targets. In foreign trade policies, it is aimed to support the cooperation of NGOs, academia, public and private sectors in order to ensure compliance with the Green Agreement within the scope of trade with the EU, to act with a common understanding and coordination in all efforts, and to increase dialogue with the EU (Ministry of Trade, 2021, p. 7)

Green Deal Action Plan, prepared by Türkiye's Ministry of Trade, stated that environmentalist, rational and sustainable transportation strategies that implement current technologies in transportation modes in the country should be specified. It aims that these strategies will contribute to the reduction of emissions in the field of transport (Ministry of Trade, 2021, pp. 8-9). The Green Deal Working Group Annual Activity Report was published in 2022. In the Sustainable Smart Transport section of the report, the "EU Sustainable and Smart Mobility Strategy" published in December 2020 is mentioned. The strategy underlines objectives such as increasing rail and inland waterway transport, supporting combined transport, launching zero-emission vehicles, disseminating alternative fuels, and developing electric vehicle infrastructure. (Ministry of Trade, 2021, p. 63).

TEN-T Transportation corridors are important and it is aimed to support the high-speed train infrastructure until 2040, to increase the capacity in freight terminals, to modernize the transportation network with a holistic perspective, and to increase the share of rail transportation in total transportation in order to improve transportation networks. The Action Plan has a vision that includes actions towards the aims desired to be achieved in the Trans-European Transport network (Ministry of Trade, 2021, pp. 62-63).

Nevertheless, logistics activities have to be in the foreground across multiple headings such as carbon border adjustments, circular economy and sustainable agriculture. There are 11 items directly associated with transport & logistics out of total 81 action items within the Action Plan. These items - listed in Table 1 - are followed by Sustainable Smart Mobility Working Group coordinated by Ministry of Transport and Infrastructure (Ministry of Trade, 2021).

Air Transport	Maritime Transport	Road Transport	Rail Transport
No. of airports to increase from 56 to 61	Increase percentage of renewable energy in ports	Create infrastructure for electric vehicles	Increase number of provinces that have and high-speed train connections from 8 to 52
Establish emission monitoring, reporting and verification	Expand green port practices	Increase use of alternative fuels instead of fossil fuels	Increase annual freight transport from 55 million to 448 million tons
Produce environmentally friendly bio-fuels and/or synthetic fuels		Reduce road transport's share in freight from 71.39% to 57.47%	Increase annual passenger transport from 19.5 million to 269.8 million
			Use of energy: 35% commitment from renewable energy sources

Table 1: Action Items (adapted from Green Deal Action Plan)

Customs Union

The Customs Union is one of the most important and central issues regarding Türkiye-EU relations, and the Union reflects the last period of the partnership relationship envisaged within the framework of the Ankara Agreement between Türkiye and the European Economic Community. The Customs Union has contributed to Türkiye's determination of more liberal and outwardly open policy strategies than protectionist policies (Nas, 2020; OPOCE, n.d.).

When the Customs Union and Green Deal relationship is examined, it can be argued that the CBAM regime will affect Türkiye. It can create disadvantages such as harming the integrity of the CU and preventing Türkiye from having fair competition conditions in the EU market. Currently, under the CU regime, Türkiye is free to export goods to Europe without proving their origin, but with the unilateral introduction of CBAM, the EU would be able to levy carbon tax from Türkiye, posing a threat that could violate the integrity of the CU (Nas, 2020).

The status of Türkiye's relations with the EU presents difficulties as the future of the Customs Union is not clear. Especially after the EU announced its "Global Europe" foreign policy in 2006, these difficulties gained momentum (Tekçe, 2015, pp. 398-399). With the modernization of the Customs Union, some sectors in the service sector might become a party to mutual liberalization. The quotas and barriers experienced by the road transport sector, the unfavorable working conditions in the service sectors, the fact that the employees have the necessary certificates, and visa liberalization stand out as important topics. (Nas, 2020).

Opportunities and Difficulties

The impact that EGM on Türkiye, also the opportunities and threats Türkiye might face will be discussed.

Opportunities European Green Deal is an ambitious plan and a comprehensive package of policy initiatives to promote transition to a low-carbon society, to tackle climate change and to foster economic growth with the definitive aim at climate neutrality by 2050. While Türkiye is still not EU member, Turkish public authorities direct their policies in all related fields, especially in trade and industry, by closely following the EU's policies and action steps. Türkiye maintains and deepens its integration with the EU and as a need for the protection of its international competitiveness (Ministry of Trade, 2021, p. 3).

Energy efficiency is a core pillar of EU Green Deal, whereas Türkiye can take significant steps towards enhancing energy efficiency in various sectors including transportation and buildings. As of 2022, there are more than 900 thousand heavy goods vehicles in Türkiye, more than grand total across EU countries. The average age of heavy goods vehicles is 17 years in Türkiye (TurkStat, 2023). When both heavy goods vehicles and light goods vehicles are able to be modernized by means of economic prosperity, decarbonization of Türkiye's road transport does have much greater area of improvement with respect to Europe (TIRPORT, 2023).

Sustainable and Smart Mobility Strategy comprises 10 key areas by the EU for sustainable, smart and resilient transport system in order to reduce transportation emissions by 90% until 2050 (European Commission, 2021). Whereas EU's Mobility Strategy aims to double rail freight traffic and establish a fully operational, multimodal Trans-European Transport Network (TEN-T), Türkiye's 11th Development Plan (2019 – 2023) was planning to increase share of rail freight in land transport from 5% to 10% (SBB, 2018). Türkiye is slowly progressing in rail freight transport volume from 14.5 billion tonne-kilometers in 2018 with respect to planned 32.4 billion tonne-kilometers by 2023. Nevertheless, President Erdogan stated "2053 Transport and Logistics Master Plan" as a guiding document to implement decisions by all relevant institutions and organizations according to Directorate of Communications (2023). The plan foresees construction of 8554 km of railway line and to invest 29 billion USD in railways until 2030. According to the environmentalist (sustainable) freight volume scenario in 2053, share of road transport (domestic & international), will reduce from 71% in 2023 to 59% in 2035, whereas share of rail transport will increase from below 5% to over 20% by 2035 and onwards (Ministry of Transport and Infrastructure, 2022; UNFCCC, 2023c).

Difficulties The European Green Deal envisions a significant shift towards sustainable transport systems. Türkiye can invest in developing low-carbon and sustainable transport infrastructure, including electric vehicle charging networks, cycling infrastructure, and efficient public transportation systems. Furthermore, integrating intelligent transportation systems (ITS) and promoting the use of clean fuels can contribute to reduced emissions, improved air quality, and enhanced mobility in Turkish cities. Türkiye is proactive in ITS studies and associations (European Commission, 2023a; Ministry of Transport and Infrastructure, 2020)

According to the decision taken by the European Parliament, light commercial vehicles and automobiles that emit carbon will no longer be sold after 2035, so that all vehicles sold are aimed to have a carbon emission reduction of 100%. Although the mentioned decision is in line with the Green Strategy, if the decision is implemented before the EU is ready for competition, it might lose the automobile market to different countries, especially China. From the perspective of Türkiye, the EGD affects Turkish trade and logistics and will heavily influence it in the future, as the EU is one of Türkiye's most important trading partners. Incentives are of great importance for Türkiye, which is trying to adapt to the EGD. The failure of Turkish companies to benefit from European incentives under the EGD might pose a great threat. SMEs carry out 98% of the trade in Türkiye. If SMEs cannot be supported with incentives for EGD, their competitiveness will be under the threat of a serious decrease (Ketenci, 2023).

CBAM is a regulation implemented to eliminate the risk of "carbon leakage" in the European Union. Within the European Union, carbon pricing already exists with the Emissions Trading System (ETS). With CBAM, it is aimed to apply a carbon pricing regulation equivalent to the ETS in current practice, to products imported into the European Union. These efforts are related to climate sensitivity. The application is also trying to implement the guidelines for manufacturers located in countries outside the European Union to reduce their greenhouse gas emissions. In this framework, a source of income that can be used to combat climate change can also be obtained. Countries with a carbon pricing mechanism equivalent to the ETS in the European Union will not be affected by CBAM and will be excluded from the scope of CBAM. Thus, CBAM will be applied to merchandise imports from third-party countries outside the European Union. For example, Liechtenstein, Iceland, Norway and Switzerland, which implement the European Union's ETS regulation, are excluded from the scope of CBAM. Establishing an ETS mechanism compatible with the EU is very important and has already become essential so that the existing trade relations between Türkiye and the EU are not adversely affected. An additional carbon tax burden on Turkish firms (especially on SMEs) will harm their competitiveness. Relevant institutions and organizations in Türkiye continue to study ETS (European Commission, 2023b; Vurdu, 2022)

Conclusion

Although Türkiye is a member of the CU, it is the only country that is not a member of the EU. In addition, it is an indispensable partner for the EU due to its geographical proximity to European countries, status as a safe transit route and potential to be a production base. This "unique" position of Türkiye has emerged once again and stronger with the announcement of EGD. Arguments such as reducing emissions with the advantage of near-shoring, strengthening and supporting maritime transport have become a priority agenda for EU countries that attach great importance to environmental sensitivity within the scope of EGD, and Türkiye is one of the most critical countries where all these EU ambitions can be achieved. Türkiye is the country where the EU can most easily implement the applications and integrate the legislation, because Türkiye is a member of the CU. Customs Union will evolve both for the benefit of European and Turkish private sectors and Turkish private sector can acquire relevant resources from EU to ensure overall economic, social and environmental benefits for the EU.

The developments in the EU affect Türkiye in multiple aspects not limited to political, economic and social dimensions. Türkiye's efforts within the scope of EGD – to comply with EGD are detailed in the study. In this context, Türkiye is making an intensive effort in the presence of the relevant Ministries, public and private sector organizations. The Action Plan prepared to clarify the EGD roadmap and establishment of the Working Group can be given as examples of these efforts. As the global trade volume increases, distances for freight transport increase. No matter how much transport technologies improve, freight transport emissions will be in an increasing trend. EU member states primarily affect transport emissions through their sectors' supply chain decisions. The way to reverse the trend in emissions from freight transport is to shorten overall distance in supply chain networks. Because Türkiye is a CU member and neighbors the EU, it is an effective option for the near-shoring decisions of European companies in terms of the implementation of the Green Strategy.

In the study, the opportunities and threats faced by Türkiye within the scope of the EGD were tried to be analyzed. European companies made direct investments in Türkiye as offshoring decisions for manufacturing. Since logistics is all about fulfilling four major requirements related to order, delivery, quality, and cost fulfillment, Türkiye, whose regulation is integrated to EU's, is uniquely positioned to incorporate environmental consciousness and social awareness for private enterprises to outsource their operations instead of other non-EU countries located in Asia-Pacific and/or America, in order to make raw materials, and commodities for European markets. Whereas Asia-Pacific market economies are growing very fast, their countries' willingness to comply with EU regulations including, but not limited to EGD might reduce European Union's negotiation

power to implement its intended policies. Consequently, only Türkiye with a stable economy and democratic political system can bring synergies for EU's competitiveness when making outsourcing decisions of goods and services as for example nearshoring.

When the situation is evaluated in terms of opportunities, it is observed that Türkiye has made an intense effort to ensure compliance of its policies with the EGD. Türkiye closely follows EU policies and action steps, and directs its policies in all relevant areas by taking into account EGD. Türkiye continues and deepens its integration with the EU, as a need to maintain its international competitiveness. Regarding threats, CBAM is considered to be a threat to Türkiye. There is talk of an ETS equivalent to CBAM in the EU, but Türkiye is neither a member of the EU nor can benefit from the ETS. In this case, CBAM may turn into a cost factor for Türkiye.

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SYSTEMATIC LITERATURE REVIEW OF THE FACTORS OF INFORMATION SHARING THAT ENABLE CIRCULAR PROCUREMENT IN THE CONSTRUCTION INDUSTRY

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Introduction

Construction is one of the most resource-intensive industries, and the recent challenges of material shortages and scarcity, with growing environmental concerns, have led to an increased and ongoing discussion of the development of circular economy (CE) models and practices (Guerra et al., 2021). CE models focus on avoiding unnecessary waste generation by reusing and recycling materials and one of the most widely adopted CE business models is the use of circular inputs i.e., replacing the linear type of resource with circular alternatives in the value chain. To this end, circular procurement plays a crucial role in this approach, as it aims to provide a new life to resources by reusing, redesigning and reducing to achieve zero wastage (Qazi and Appolloni, 2022).

According to the United Nations Environment Programme (UNEP) “Circular procurement occurs when the buyer purchases products or services that follow the principles of the circular economy, supporting the assessment of designing, making, selling, reusing and recycling products to determine how to get the maximum value from them, both in use and at the end of their life” (UNEP, 2021). Studies have highlighted the importance of information sharing to achieve CE aims and objectives (Jäger-Roschko and Petersen, 2022). Knowledge management facilitates the creation, sharing and transfer of information to address CE challenges (UI-Durar et al, 2023).

Although there is sufficient literature on knowledge management (e.g., Jamal and Tilchin, 2016; Paulin and Suneson, 2015), as well as the conceptualisation and development of circular supply chains (e.g., De Angelis et al., 2018; Sudusinghe and Seuring, 2022), there are a few studies that try to focus specifically on procurement activities and which identify the barriers and enablers for a transition to circular procurement (Al-Sinan and Bubshait, 2022; Qazi and Appolloni, 2022). There is a call for further research into knowledge management and CE (UI-Durar et al, 2023). To the best of the author’s knowledge, there are no studies that try to explore the link between knowledge management and circular procurement. This study seeks to fill this gap by establishing the factors that influence knowledge management’s effectiveness to support circular procurement within the construction industry. The following research question will be addressed:

RQ: What are the drivers and barriers that support the effective implementation of KM to enable circular procurement in construction supply chains?

The rest of the paper is arranged as follows. Section 2 provides the methodology adopted for the systematic literature review. Section 3 outlines the descriptive statistics of research papers and the thematic analysis findings of enablers and barriers of CE procurement practices. In section 4, conclusions and limitations are discussed and future research directions are proposed.

Methodology

A systematic literature review process was adopted. The six-step process proposed by Sauer and Seuring (2023) was followed which are discussed below.

Step 1 and Step 2: Define the Research question and the characteristics of the primary studies.

During the initial stage, the two researchers developed a review protocol to collect relevant studies based on the research question presented in the introduction section. This protocol was based on identifying peer-reviewed journal papers, written in English, that were explicitly focused on CE procurement activities in the construction industry.

Step 3 and Step 4: Retrieve the relevant studies and choose the most appropriate.

Data were collected through the ProQuest database using the search terms: “purchasing” OR “procurement” (ABS) AND “data” OR “information” OR “knowledge” AND “circular economy” AND “construction”. This initial search generated 471 papers and after duplicates, conference papers and a detailed review of the research focus, the sample was reduced to 25 papers that were analysed for this paper.

Step 5 and Step 6: Thematic analysis and reporting the results.

An Excel worksheet was prepared and shared between the authors, to analyse the papers based firstly on descriptive statistics such as the trajectory of the research, methods used, country focus and theoretical underpinnings. A thematic analysis using a framework from Veer Ramjeawon and Rowley (2020) was then done to establish qualitative barriers and enablers to the implementation of CE procurement in the construction industry.

Findings and discussion

Descriptive Analysis

Trajectory of research

The papers were analysed based on their date of publication to establish if this is an increasing area of research. Perhaps unsurprisingly, given the recent focus on the concept of CE at multiple levels, there has been a significant increase in the number of papers published.

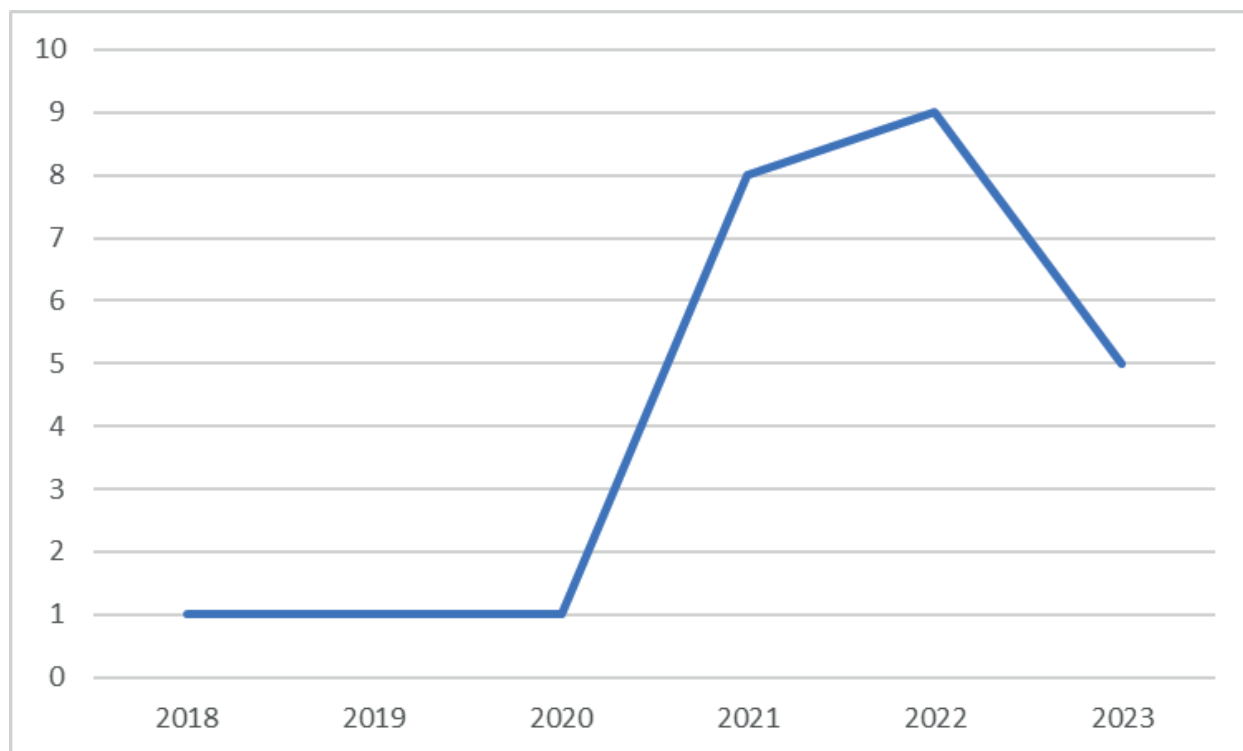


Figure 1: Number of papers published per year

Methods used

Although there is a mix of different methods used, the cumulative higher numbers of non-empirical papers (i.e., secondary, literature review and conceptual) suggest that more empirical research is needed, as this would further develop the field’s understanding of the application of CE procurement activities in the procurement industry.

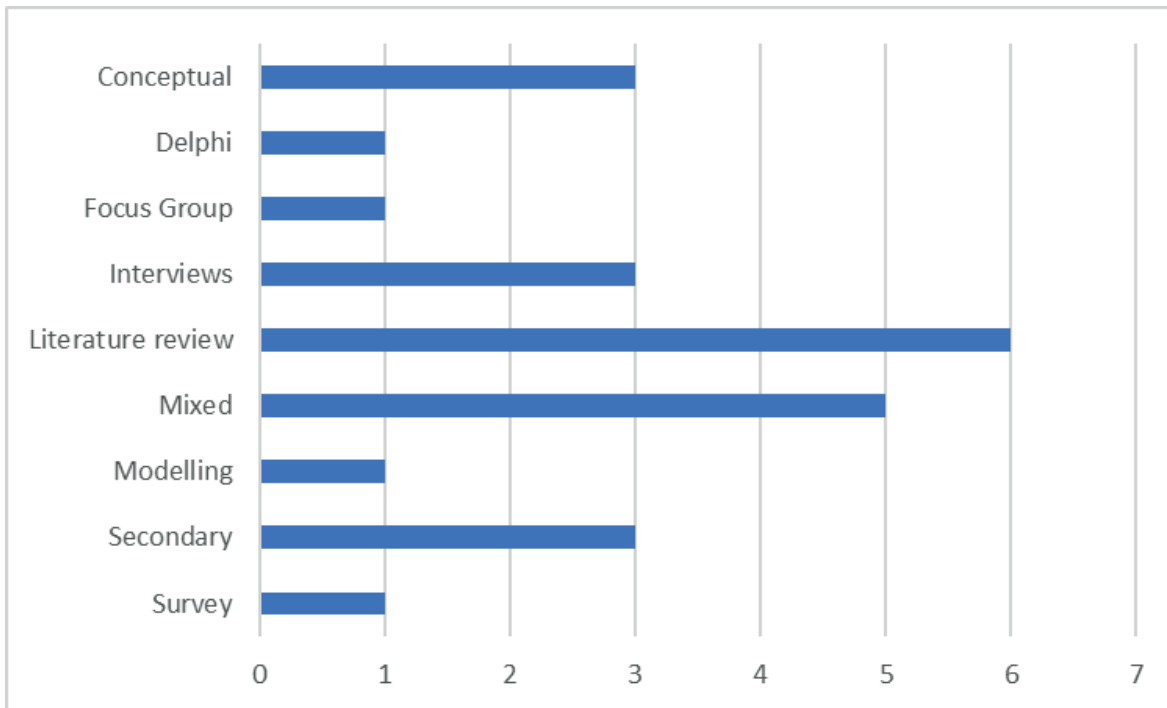


Figure 2: Number of papers published by the methodology used

Country Focus

Although a number of specific countries were focused on in the research, many of the papers were not specific as to the region being investigated and a wider range of countries could be researched to expand a global understanding of how CE procurement techniques have been adopted in the construction industry.

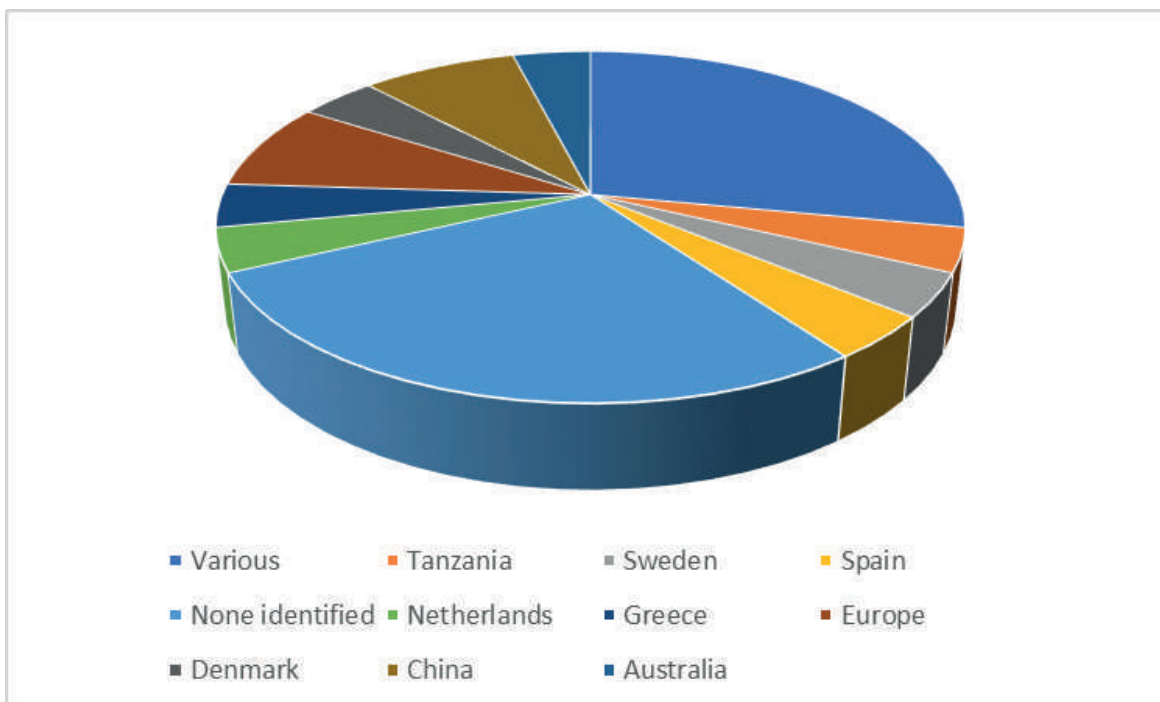


Figure 3: Number of papers published by country focus

Theoretical focus

The papers analysed were atheoretical in nature and this finding suggests that a greater use of theory (particularly ‘grand’ ones) would provide an opportunity for a more sustained contribution to the academic field.

Thematic Analysis

Table 1 summarises the enablers and barriers that enable the knowledge sharing of circular procurement in the construction industry.

Aggregate dimension	2 nd order code	1 st order
Strategies and policies	Poor conceptualisation of circular procurement	“[concept of] circular procurement is not widely shared” (Qazi and Appolloni, 2022) “Limited circular procurement practices and strategies in construction” (Wuni, 2022)
	Lack of governmental guidance	“Lack of government support in terms of financial incentives and benefits to incorporate circularity” (Qazi and Appolloni, 2022) “The scope of GPP law being limited and the policy framework being incomplete” “a lack of information on how to set realistic GPP requirements for recycling and reuse options” (Wang et al. 2020)
	Need to establish harmonised standards for recycled materials and/or certification schemes	“...an urgent need to introduce a global framework and a practicable pathway to allow companies to implement such models, regardless of their scale and location” (Callun et al., 2022)
Organizational structures	Resource allocation	“Allocate adequate budget and resources to implement SPM principles” (Ershadi et al., 2021)
Rewards and incentives	Supplier focus	“Suppliers with the potential to provide innovation indicate that the lack of interaction and understanding with the procuring organisations and over-specified demands in tenders consist the main barriers for innovation procurement” (Milios, 2018)
	Governmental focus	“Policy incentives should facilitate a shift away from incineration and low quality recycling towards developing cleaner material cycles and high quality recycling.” (Milios, 2018)
Leadership	Senior management commitment	“Management support [has] a significant positive relationship with sustainable procurement” (Masoud 2023) “Circular procurement is not among the priority of top management” (Qazi and Appolloni, 2022)
Human resources	Internal knowledge	“Staff knowledge [has] a significant positive relationship with sustainable procurement” (Masoud 2023)

	Supplier knowledge	"Supplier is not willing to implement circularity due to lack of knowledge, information, and skills" (Qazi i and Appolloni, 2022)
	Client knowledge	"Knowledge and awareness of environmental criteria, environmental performance and technical expertise among clients" (Lingegård et al., 2021b)
	Training	"...procurement team is not trained for circular Procurement" (Qazi and Appolloni, 2022)
Culture	Resistance to change	"...resistance to change regarding procurement, passive and reactive culture in the supply chain." (Lingegård et al., 2021b)
	Trust	"...fostering the trust between the relevant parties" (Bao et al., 2019)
Technology	Blockchain	"Blockchain needs (i) infrastructure for data management, (ii) advanced applications and archetypes, and (iii) customers' demand, interest, and tendency, and (iv) taxation and reporting" (Sadeghi et al., 2022)
	Building Information Modelling	"Building Information Modelling (BIM) allows the construction of a digital scale model of the asset to be built, ensuring the early detection of conflicts and interferences, enabling communication between the different participant agents, and facilitating the processes in the maintenance and management phase" (Pérez-García et al., 2021)
Linkages	Fragmentation and complexity	"Fragmentation and complexity of the CE supply chain network in construction" (Wuni, 2022).
	Lack of suppliers	"Insufficient suppliers of circular materials and products" (Wuni, 2022) "Lack of complete supply chain network" (Wuni, 2022) "Lack of designers, contractors and planners" (Banihashemi et al., 2023)
	Collaboration and integration	"The collaboration among all the stakeholders (e.g., the policymakers, the users, buyers and vendors) is critical in its successful implementation." (Wang et al., 2020) "Lack of integration and collaboration among supply chain partners in construction" (Wuni, 2022)

Table 1 - Enablers and barriers to information sharing that enable circular procurement

Strategies and policies are important enablers of knowledge creation of circular procurement in the construction industry. According to Castell-Rüdenhausen et al. (2021), national and local CE policies incentivised CE actions and companies should adapt and add their selection criteria to avoid selecting suppliers that cannot meet minimum sustainability requirements (Ershadi et al., 2021). In particular, the public sector can use its purchasing power and set requirements for implementing GPP tender processes (Pellegrini et al., 2021). However, the expectations on how to set realistic GPP requirements are not clear and at the same time, the information on the availability of recovered and reusable materials is not easily available among stakeholders (zu Castell-Rüdenhausen et al., 2021).

Other barriers that were identified are the lack of awareness of sustainable procurement practices amongst procurement managers and the lack of a focused organisational culture that recognises the importance of the successful implementation of sustainable procurement (Ershadi et al., 2021). To this end, it is highlighted that there is a need for training so that the procurement department can develop professional skills and expertise on how to implement sustainability and circular procurement goals (Ershadi et al., 2021). Practitioners could support and create awareness (Lingegård et al., 2021a). To generate tangible results a well-trained, ethical and professional staff is needed through all the stages e.g., tendering, bid evaluation, and contract verification (Wang et al., 2020).

The leadership of project managers in the construction industry is also recognised as an important enabler. Project managers need to assign and observe the contribution of each party to the sustainable procurement process (Ershadi et al., 2021). Project managers need also to set boundaries to avoid any miscommunication and reworks. Thus, collaboration is key to minimising resistance to change and promoting knowledge sharing (Lingegård et al., 2021a). Non-collaborative culture is one of the key causes of waste generation (Pellegrini et al. 2021). For example, Milios (2018) has indicated that there is a lack of information or asymmetric information as usually, only the suppliers are aware of the quality and properties of potentially recyclable or reusable materials. Digitalization and digital tools can support accessing information on forthcoming material availability (zu Castell-Rüdenhausen et al., 2021). Pellegrini et al. (2021) suggested the use of blockchain technology to enable smart contracts that can guarantee secure and trustworthy information, thus trusted transactions and agreements in GPP.

Conclusions

Although circular procurement is essential for promoting and implementing CE principles through various supply chains, it has not been widely adopted yet. There is also a lack of studies that tried to identify the enablers and barriers of information sharing that will facilitate it. Therefore, this study used a systematic literature review to identify and categorise the enablers and barriers of creating, sharing and transferring circular procurement-driven knowledge in the construction industry. Barriers identified included a lack of governmental guidance, standards and appropriate conceptualisation of circular procurement. Several studies also highlighted that managers also play a key role in disseminating knowledge and pushing circular procurement principles and activities within their own company.

The lack of a knowledge-sharing culture among suppliers and clients was also identified as a key challenge. Enablers were perceived to be qualified and experienced procurement staff which can be only achieved through training but also by utilising emerging technologies, such as Blockchain, as smart contracts can facilitate the transition to circular procurement.

The identified enablers and barriers offer enhanced guidance and help companies in the construction industry to systematically recognise the extent to which they are capable of increasing the robustness of sharing information among various stakeholders to achieve their circular procurement and therefore wider CE aims and objectives. As with any other study, this research has limitations i.e., the method applied but also specific circular procurement practices have not been captured in detail. Future research could discuss these practices by developing a robust theoretical framework. Conducting case-study research and using primary data would also enable more focused insights to be generated and this, along with a more explicit use of the theory, would help the development of the field.

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SUSTAINABILITY PERFORMANCE IN THE MARITIME TRANSPORT: A LITERATURE REVIEW AND FRAMEWORK

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1. Introduction

Maritime transport constitutes over 80% of the total global trade volume and is responsible for transporting cargo across all major ocean routes and water bodies of the world. It is an essential component of the supply chain (Yang and Wei, 2013) and facilitates international trade. However, maritime transport has a complex and extensive network comprising various stakeholders, such as shipowners, terminal operators, shipbrokers, shippers, freight forwarders, port authorities and governments (Xiao et al., 2021).

Although maritime transport promotes global economic development (Lun et al., 2014) and international trade, shipping operations have a negative environmental impact and are responsible for greenhouse gas emissions, waste, noise pollution and the generation of toxic materials (Gavronski et al., 2011). To add to these deleterious effects, ocean pollution has a negative influence on society and harms commercial activities, such as fisheries and the quality of life for individuals residing in coastal communities (Ellram and Murfield, 2017). Consequently, sustainable management activities in the shipping industry are identified as one of the biggest current challenges (Koilo, 2019).

The purpose of this paper is to review the sustainability of the maritime transport industry. This paper also presents a framework for evaluating the sustainability performance of maritime transport. A systematic literature review (SLR) was conducted to investigate previous literatures that have dealt with the theme of sustainable management activities in the maritime transport industry. The review questions are:

RQ1: What are the research trends of sustainability of maritime transport?

RQ2: What are the drivers of sustainability performance existing in maritime transport sector?

RQ3: What are the key indicators of maritime transport sustainability performance?

2. Methodology

To explore the implementation of sustainability in maritime transport, this paper adopts a SLR method to answer the research questions. This paper adopts a five-stage SLR process proposed by Tranfield et al. (2003) to analyse and synthesise the literature in this paper. This review method will be used to minimise errors and avoid bias in analysing the collected journal papers. This process includes: (1) Question formulation; (2) Locating studies; (3) Study selection and evaluation; (4) Analysis and synthesis; and (5) Reporting and using the results.

The keywords were adopted in the Web of Science and Scopus databases within the title, abstract and keywords, from 2000 to 2022. A total of 1971 papers were retrieved, identifying 1168 papers from Scopus and 803 papers from Web of Science.

In the initial screening process, to increase the reliability of paper selection and ensure the inclusion of papers most relevant to the research purpose, an inclusion-exclusion filter was applied to narrow down the scope. The inclusion and exclusion criteria for selecting papers is demonstrated in Figure 1. Based on this, the number of papers was decreased to 447. Non-accessible papers, conference articles, book, non-English, and duplicate searched papers were excluded at this stage.

After that, abstract analysis was performed. In this process, papers not enlisted on ABS 2021 or SSCI/SCIE were eliminated. Also, irrelevant topics to the main research and question were excluded, and only 149 papers were identified.

Lastly, a separate context review was thoroughly conducted based on the previously formed research questions and

inclusion and exclusion criteria. After evaluating the overall context of the paper, an additional 96 papers were removed, and a total of 45 papers were adopted which covers helpful information in answering the research question. Through the screening process, the number of papers decreased from 1971 to 45 as Figure 1.

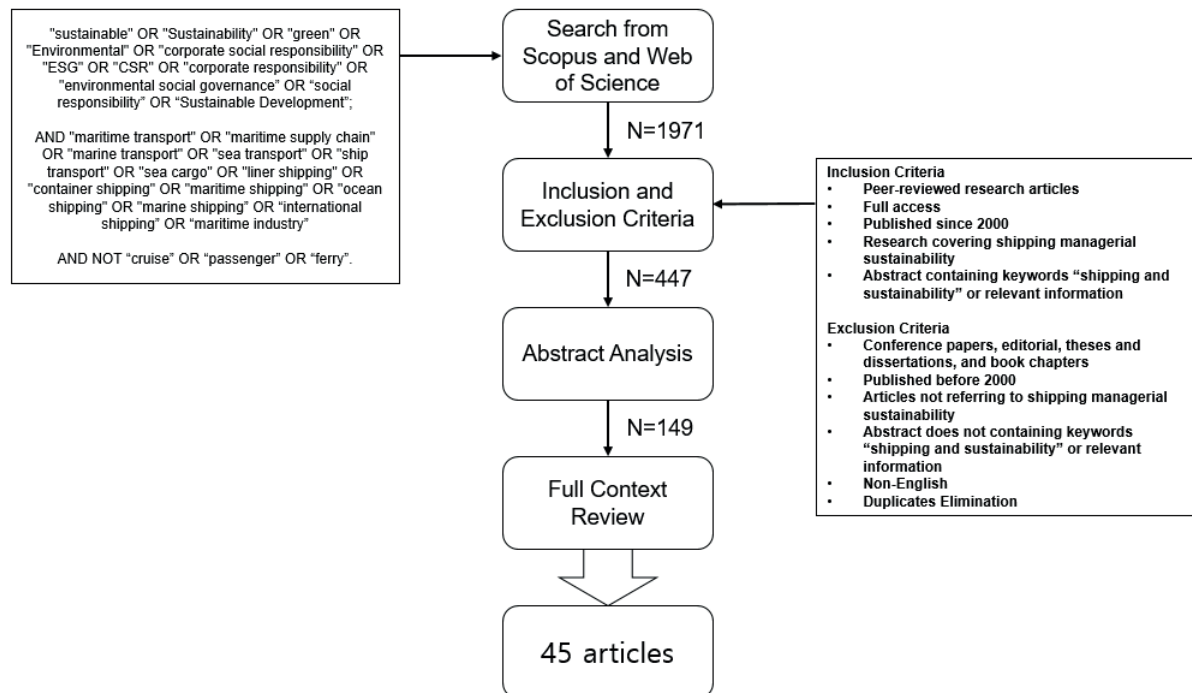


Figure 1 Article Selecting and Filtering Process

3. Discussion

3.1 What are the research trends of sustainability of maritime transport?

A comprehensive analysis of article trends in this area clearly shows that there has been a recent interest in maritime transport sustainability. With the gradual increase in the number of publications in recent years, it is evident that research on sustainability in the maritime transport industry has become more prominence and established itself. In this field, research has progressively focused on exploring the correlation between environmental or social impact, firm performance, and customer satisfaction. Consistent with substantial research on sustainability, the crucial positive link between environmental, social and economic issues is emphasized. In particular, the advantages of sustainable management activities generated improving service quality and competitiveness.

When the centre of research is on maritime transport sustainability, Asian shipping companies are more noticeable, although the first research started in Europe. In this regard, maritime transport companies from Singapore and Taiwan have highlighted in studies on international environmental responsibility and governance. The increase in research evaluating shipping sustainability in Asia is likely due to the world's busiest and largest ports such as port of Singapore and major shipping routes departing from Asia.

The other observed trend is the terminologies used in the research. These terms include: environmental, social, and governance (ESG), green, sustainable development, corporate social responsibility (CSR), and sustainability. The prominently adopted terms are sustainability and sustainable shipping management. It was observed that the reviewed papers initially focused only on environmental aspects using the term green, but as time passed, scholars began to consider other aspects as well as the environment with the term CSR, sustainability, and ESG. For example, studies at an early stage like Lai et al. (2011), Yang et al. (2013), and Lim et al. (2014) were related to the environment. There have been papers that have analysed CSR at this stage such as Fafaliou et al. (2006) and Lu et al. (2009), but they have mainly focused on the environment. After 2015, studies using triple bottom line began to increase. In recent studies, the terms CSR and sustainability tend to be used interchangeably.

3.2 What are the drivers of sustainability performance existing in maritime transport sector?

The first identified driver is initiatives, which encompass international and regional level. An illustration of an international initiative is the International Maritime Organization's (IMO) international convention for the Prevention of Pollution from Ships (MARPOL), which establishes standards for the reduction of NO_x, SO_x, and emissions of particulate matter (PM) from ships (Skovgaard, 2014; Poulsen et al., 2016). IMO introduced two new evaluations, in 2013, the energy efficiency design index (EEDI) and the ship energy efficiency management plan (SEEMP) were introduced to enhance the environmental performance of maritime transport by reducing CO₂ emissions. The SEEMP is a compulsory plan applicable to all ships, with the objective of reducing fuel consumption in ship operations. The EEDI aims to reduce CO₂ emissions in comparison to the operations activities of new ships. Also, there are regional level voluntary initiatives. For example, from 2018, the European Union (EU) introduced a program known as the Monitoring, Reporting, and Verification (MRV) scheme to monitor and verify CO₂ emissions from the shipping industry. The development of regulations, standards, and plans shows mounting pressure on shipping companies to actively contribute to sustainability through both mandatory and voluntary compliance. The sustainability related policies and regulations are crucial drivers for shipping companies to move towards sustainable development.

The next driver is pressure. Pressure can be classified based on the entity exerting it. One is pressure from competitor. Pressure from competitor, for example, Maersk's proactive endeavours to address environmental governance are not only reshaping the company but also transforming the industry as a whole (Alger et al. 2021). In an already low-margin shipping industry, new environmental regulations tend to increase shipping costs. However, companies like Maersk, which has economies of scale from having mega-vessels and benefits from cost savings from alliances, has less financial impact than smaller companies. An unavoidable outcome of rising operating costs is industry consolidation, which manifests through the bankruptcy of smaller companies, mergers and acquisitions, and strengthened entry barriers for aspiring companies. Maersk increases its industry dominance by raising environmental requirements and increasing risks and costs to competitors. In other words, major players such as Maersk are leveraging their market dominance and industry stature to set the scope and direction of environmental governance, enhancing their competitive advantage in the process. The other is pressure from customer (Skovgaard, 2014; Poulsen et al., 2016; Alger et al. 2021). As a response to the increasing environmental concerns of end customers, shippers have embraced environmental upgrades as a novel business strategy aimed at gaining control over the supply chain and boosting sales. This pressure to be green is shifting from end customer to upstream, imposing shipping companies to be green (Poulsen et al., 2016). For instance, shippers are showing a growing interest in addressing shipping emissions as a means to mitigate environmental impact and enhance sustainability. Cargo-owners are concerned about CO₂ emissions and it is a crucial driver for environmental upgrades in maritime transport. With sustainability disclosure, Customer demands can be met and alleviate the pressure (Zhou et al. 2021).

The third driver that has been identified is the chance to enhance performance and lower costs (Skovgaard, 2014). A better resource and waste management can support the environment, but also lessen costs. For example, pollution prevention through substituting material and eliminating waste reduces costs of disposal and other related costs. Lastly, cooperation and maintaining long-term relationships with diverse stakeholders. Through cooperation, shipping companies and stakeholders can combine resources to achieve mutual benefits while jointly addressing common sustainability challenges (Tran et al. 2021).

3.3 What are the key indicators of maritime transport sustainability performance?

The commonly used environmental indicators included 'Water management', 'Air emissions', 'Energy', and 'materials'. These indicators can be regarded as core environmental indicators. Numerous indicators related to maritime transport operations have been examined in the literatures. These indicators encompass inputs like materials and cleaner technologies, as well as outputs such as waste management, environmental compliance, noise pollution and ecosystem. Furthermore, atmospheric contamination is recognised as a critical indicator, and numerous experts concur that shipping operations should concentrate to improve air quality to achieve sustainability goals.

With regard to the social dimension, 11 measurements were figured out from the articles: 'Safety', 'Health', 'Security', 'Education and training', 'Community involvement', 'Equality', 'Employees', 'Transparency', 'Compliance', 'Customer relation', and 'Business ethics and codes of conduct'. 'Education and training', 'Community involvement', and 'Transparency' were the most interesting measurements for researchers.

The most commonly employed economic indicator was 'profitability', which is regarded as a salient indicator of increasing performance, as shipping sustainability practices have positive effects on firm competitiveness.

3.4 Research Gaps

This SLR provides insights on shipping sustainability from a management perspective and provides guidance for future research. Based on the above review, several research gaps were identified that will enrich research in maritime transport sustainability and summarised as follows:

- 1) Most of the existing frameworks mainly presupposes preferential independence among indicators. Studies defining interrelationship and interdependencies were scarce.
- 2) Most of the existing literature does not reflect the preferences and expectations of stakeholders. Although there is a clear difference in perception among stakeholders and shipping companies, and participation of these stakeholders is helpful in improving sustainability, only few study included stakeholders in the framework development phase.
- 3) Finally, most of the existing studies on the sustainability of maritime transport seem to consider 'sustainability assessment' as a criterion of existing performance from the triple bottom line perspective. In other words, these studies did not take into account the performance drivers that link these measures to long-term firm strategies and goals.

4, Conceptual Framework

The SLR conducted above has set the initial conceptual framework that can be used to assess sustainability performance for maritime transport. The initial proposed model is a hierarchical model with drivers linking sustainability performance to three domains. It is, therefore, required to test the sustainability dimensions' balanced consideration in a set of identified factors. It is noteworthy that the distribution of items is not the same for the three categories, as each dimension has a different focus and purpose of each assessment category. Figure 2 shows the conceptual framework of this paper.

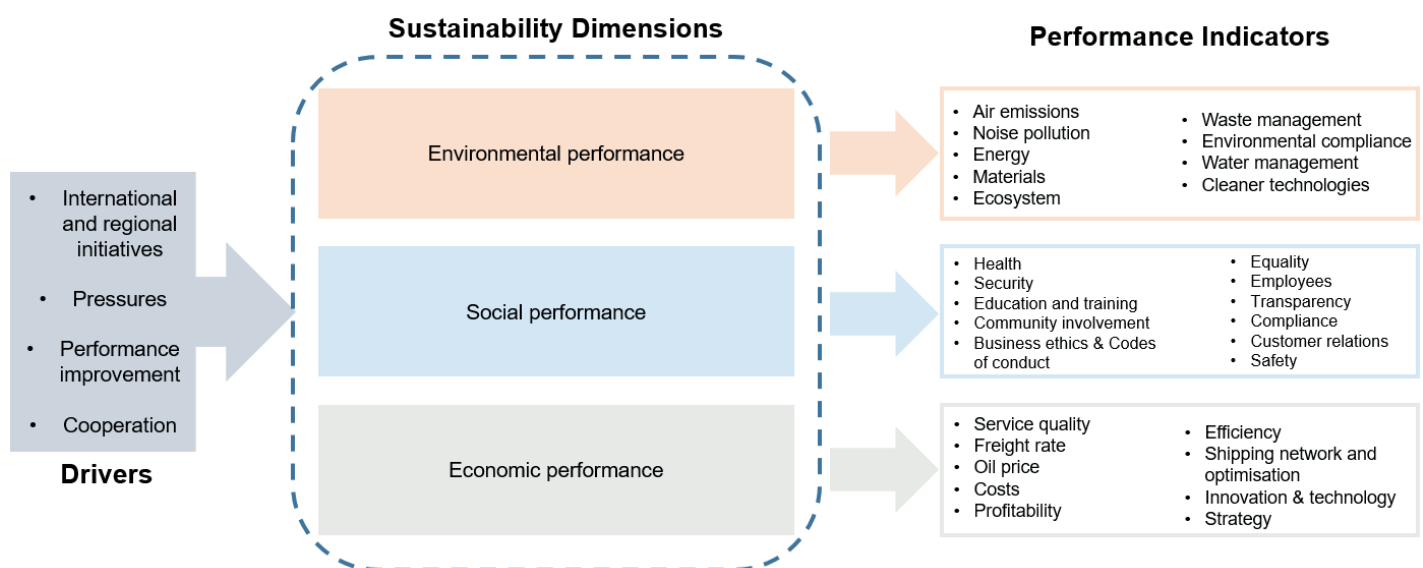


Figure 2 Conceptual Framework

5. Conclusion

This paper investigates current state-of-the-art sustainability of the maritime transport industry and develops a framework for evaluating the sustainability performance of maritime transport. This paper used a five-stage SLR process which was proposed by Tranfield et al. (2003) to search, select and analyse literature.

The contributions of this paper can be concluded as follows. Firstly, this paper conduces to the identification of research on maritime transport sustainability by providing critical analysis and evaluation of empirical and conceptual works.

Second, this paper present the key indicators and conceptual framework for the maritime transport sustainability performance assessment across the three dimensions of sustainability. This information is useful for practitioners, particularly decision-makers involved in the implementation of sustainability practices.

Additionally, the critical analyses of previous studies on sustainability in the maritime transport context can provide solutions to aid decision-making undertaken by policymakers.

Lastly, by addressing the research questions, a summary of research trends and current research content on sustainability performance of maritime transport is presented. Additionally, research gaps were identified, which provide opportunities for further research on the sustainability performance in the context of maritime transport.

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STRENGTHS AND WEAKNESSES OF 3PL COMPANIES IN SUPPORTING WOMEN'S LEADERSHIP IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

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Introduction

The role of women in companies' governance systems is acutely limited. High demand labour markets, enhanced higher education of women, and dynamic industry and firm conditions could result in a greater participation of women executives in firms moving toward major corporate status (Nelson, Levesque, 2007). Across the world, women remain a minority on corporate boards (Brieger et al. 2019; Carrasco et al. 2015; Grosvold et al. 2016). The primary reason for this, is that high level company management does not expect benefits from gender-diverse boards. Furthermore, organizations face little pressure to change due to the small number of companies that have already adopted respective governance code recommendations. (Mensi-Klarbach, H., Leixnering, S. & Schiffinger, M., 2021).

There is a convincing evidence that there are a lot of benefits from employing women managers in logistics and supply chains. Women are more likely to make ethical choices than men and years of women's experience in their jobs is correlated with higher level of ethical behaviour (Glover et al, 2002). Women have greater sensitivity to social issues and increase corporate governance practices, which constitute a mechanism that strengthens business ethics and mitigates frauds and corruption in companies (Machold et al., 2007). „Smart companies appreciate that diversifying their boards with women can lead to more independence, innovation, and good governance and maximize their company's performance.” (Companies With More Women..., 2004). Irrespective of their cultural origin, women are keener than men to collaborate to achieve a common goal. Women leaders play an important role in understanding and addressing customer needs, since roughly 50% of the population are women and 80% to 85% of all consumer decisions are made by women (Wilson, 2017).

Another perspective of women's leadership and high level management positions is diversity. Diversity in the workplace means that an organization employs a diverse team of people that's reflective of the society in which it exists and operates. Diversity means that the workforce is made up of employees with different races, gender identities, career backgrounds, skills and so on. (Daley, 2022).

Improving diversity and inclusion, related also closely to the participation of women in company and supply chain governance, will be one of the main interests of just about every company in the future. Commitments towards more advanced solutions in the area of diversity and inclusion, should be approved by each company's board of directors.

Problem description

Supply chains are built on the basis of participation of many stakeholders and different types of participating companies. 3PLs are one the crucial links in logistics and supply chain structures, but other types of companies play an equally important role (i.e. manufacturers, sales companies and all types of intermediaries). In order to create a responsible company as a part of integrated supply chain, companies have to prove a responsible governance. They have to implement a governance strategy to make sure that all company decisions align with their stated values. Companies act by creating a governance structure. Proper governance ensures that company decisions align with stated company values and can provide the operational and strategic transparency. Governance for the responsible supply chain takes collaboration, formalization, and additional mechanisms (Supply Chain Governance... , 2021).

Diversity and inclusion are some of the aspects of supply chain and participating companies governance. Inclusion refers to the intentional, ongoing effort to ensure that diverse people with different identities are able to fully participate in all aspects of the work of an organization, including leadership positions and decision-making processes. This should be secured by proper governance systems.

The results of published research show that the mean of the diversity management disclosure level is very low. Also some research proved that there is a positive relationship between the board size, women on board and board independence and

the level of diversity management disclosure. The relationship is higher with more board members, women on board and more independent directors. (Shohaieb, Elmarzouky, Albitar, 2022).

With the increased attention to diversity, organisations are under increasing social and political pressure try to employ their diversity management practices, but with respects to women management and leadership support they are not successful in many cases. It has been demonstrated by the report entitled “Women’s leadership in logistics – where are we and what comes next?” which was published in December 2022 (Trochymiak, Kisperska-Moron, 2022). The main aim of this report was to recognize and define the potential barriers on the way to career advancement of women in logistics in Poland, especially in the area of promoting them to higher managerial and executive positions.

The current study has been a logical continuation of the Report from 2022 and its purpose is to verify the influence of companies’ governance on job modelling for supply chain leaders and managers in 3PL companies in order to maintain a rational balance of impact of men and women on strategic changes in companies.

In order to achieve this goal the following research questions have been formulated:

RQ1: What are the main strengths of governance at 3PL companies in supporting women’s leadership?

RQ2: What are the main weaknesses of governance at 3PL companies in the process of accepting women’s leadership?

RQ3: What differences and similarities between 3PL companies and manufacturing companies occur in the process of including women managers into logistics and supply chain management governance?

Characteristics and methodology of the research

The research was based on the case studies of 15 business organizations operating logistic processes. The group included 6 multinational 3PL providers, 3 national 3PL providers and 6 in-house logistics departments or service providers for particular industry corporations.

Table 1 shows the characteristics of the organizations and their representatives who were respondents in our research.

Case No.	Type of business	Company size	Respondent’s position
1.	multinational 3PL provider	more than 500 employees	Marketing Director
2.	multinational 3PL provider	more than 500 employees	CEO
3.	multinational 3PL provider	more than 500 employees	Local Sales Director
4.	multinational 3PL provider	more than 500 employees	HR Director
5.	multinational 3PL provider	more than 500 employees	Forwarding Manager
6.	multinational 3PL provider	more than 500 employees	Vice-President
7.	national 3PL provider	up to 500 employees	Forwarding Director
8.	national 3PL provider	up to 500 employees	HR Director
9.	national 3PL provider	up to 500 employees	Forwarding Manager
10.	in-house logistics departments/ service providers (building sector)	more than 500 employees	Logistics Director
11.	in-house logistics departments/ service providers (wind solutions industry)	more than 500 employees	Logistics Director
12.	in-house logistics departments/ service providers (FMCG)	more than 500 employees	Customer Operations Manager
13.	in-house logistics departments/ service providers (pharmacy sector)	more than 500 employees	Supply Chain Manager

14.	in-house logistics departments/ service providers (power industry)	more than 500 employees	Logistics Project Manager
15.	in-house logistics departments/ service providers (health & beauty sector)	more than 500 employees	Deployment & Customs Operations Manager

Table 1. Characteristics of the companies in our research and the respondents

The research, carried out in May 2023, used the methodology of structured interviews – telephone or face-to-face. Each respondent was asked 4 questions:

1. Can you, as a manager, influence the key decisions in your organization?
 - A) What exactly can you influence, what decisions can you make?
 - B) Are your decisions always approved?
2. Are you a part of the process to build a more diverse, inclusive and fair work place?
 - A) If you are a part of this process, explain to what extent. If you are not, explain why.
 - B) How do you understand more diverse, inclusive and fair work place?
3. What needs do you see in shaping the women's leadership in your company and which women's competences could be utilized better?
4. Are there any cases in your organization where job profiles are based on the stereotypes of female and male roles?

Research studies

Scope of the decision-making power

Regardless of the size of the organization, type of business and position of the respondents, they all confirmed that their decision-making power is unrestricted within the scope of responsibilities on their positions. They did not describe any cases of gender discrimination related to their managerial positions. The respondents have full decision-making power with respect to selection of their team members, organization of work and access to necessary resources, managing processes, delegating tasks and selection of subcontractors. On the other hand, when it comes to the budget-related decisions, corporate investments or finances, as well as strategic development, the respondents do not have any real impact on these issues or any real independence in making relevant decisions. In most cases their views, ideas or suggestions in this respect were rejected by the company management. This was a common opinion, expressed by the representatives of both logistics providers and in-house logistics departments or logistics service providers for particular industry corporations.

The respondent in Case 15 said that both herself and her fellow-managers have real impact on the selection of team members, delegating tasks and organization of work. "I have influence on the people, I can decide how to utilize their potential for the benefit of the company. I have no influence on the budget, which is managed by my boss – Senior Regional Logistics Manager – so I can't fully control the situation in my work area. Everything related to budget must be approved by my manager, e.g. the level of employment, so I'm not really independent in this area. I feel all the cost elements are controlled by someone else. I believe that I could make some of these decisions independently, e.g. those related to trainings or bonuses, without the approval from my boss."

This observation was confirmed by another example of Case 2. The respondent commented: "I am the only woman on the Group Management Board (of 5). In this very masculine, environment all my decisions, as a woman, are usually challenged, even though I'm in charge of 6 companies in the Group. Generally, I have influence on the work organization and contracts with subcontractors. However, when it comes to investments or major changes in my business units, I need to get an approval, which means I need an approval whenever higher budgets are concerned."

Also, Case 13 shows an example of a restricted decision-making power. “I can influence a lot of decisions related directly to my position, such as operational elements, organization of the supply chain, flow of information, delegating tasks and selection of team members. It doesn’t matter that I’m a woman here. I feel much more discomfort as a woman, when it comes to the joint decisions, made with other departments. If there are two equal-level managers – a woman and a man – the woman’s decision will always be challenged, while the man’s decision will be accepted. Even the smallest mistake made by a woman will be remembered and reminded for long, while even the biggest mistake made by a man will be seen as something natural, as everyone can be wrong sometimes. It is shocking, because, no matter how high my competences are, my male colleagues, even less skilled, will always be more appreciated and respected than me.”

Strength of women’s leadership versus diversity policy

In order to assess the situation of women leaders in logistic processes more thoroughly, we must look closer at individual business organizations and positions occupied by the respondents, comparing the two research categories: 3PL providers (both multinational and national – 9 organizations) and in-house logistics departments or logistics service providers for particular industry corporations (6 organizations).

Analysis of the research outcomes for the in-house logistics departments or logistics service providers shows the absence of major barriers and negative occurrences, or deliberate negative behaviors related to promotion of diversity in the organizations and leadership. The companies have implemented or are implementing standards and regulations of equality and diversity. They are introduced across the board, in all branches, at all levels and for all employees, even though only a few years back these organizations were dominated by men. Advancement of the equal opportunity policies, imperative to observe the ESG principles and commitment to introduce parity rules induced major changes of the organizational culture in these corporations. The respondents representing this group point out that their companies put the pressure on implementation of the diversity & inclusion policy not only inside their own organizations, but also among their suppliers and subcontractors. These companies see diversity as a major strength and driver of their business growth. This attitude is reflected in the research respondents’ comments.

The respondent in Case 10 says, “Until recently I worked with managers who were older than me, which meant that as a younger woman I had to fight for my position. Now, as the Logistics Director in the new organization I can see that the equality rules are clear and observed. Another thing is that here all the managers are in similar age. So, it is different, I am heard and respected. Of course, it’s the question of organizational culture.”

The respondent in Case 12 also describes similar experiences “For 20 years I have sat on the FMCG company boards and I haven’t had any negative experiences. In my career I haven’t had any situation where men had more opportunities than women or were required less. Women have always been appreciated for our perspective, which may have been a little different, but multi-angle and unique. In our company everybody is treated equally. This is because of our organizational culture and people’s attitude, which is about being open-minded and respectful, listen to others and pursue our common goal, not individual private goals. This is the strength of our organization.”

The situation is different in the other group – 3PL providers. Despite the fact indicated by the respondents representing these 9 companies in our research, that their organizations understand the necessity to implement the diversity & inclusion policy, or are already implementing this policy, the pace of the changes is very slow. Without an external factor, which would additionally enforce the changes, they are introduced very late. The respondents emphasize that the logistic industry still maintains traditional conservative attitude and thus, the process of implementation of diversity & inclusions principles is too slow. This is clearly expressed in the comments from the 3PL group respondents.

For example, the respondent in Case 7 says directly that “We don’t have any diversity policy, we’re only working on it now. We can see the pressure from our employees to speed up the implementation, but it’s really difficult, mainly because of our CEO’s attitude. He says ‘I don’t mind if we implement these principles, but I make the decisions here.’ So, it all depends on his decision, and for him it certainly isn’t the top priority. We’d have to have some external driver, e.g. some customer’s requirement. Then the process would go much faster.”

The situation is similar in Case 6: “The logistics industry is quite reluctant when it comes to changes. We’ve seen it for many years in many companies. And sometimes we need some revolutionary changes to operate differently, to become more flexible. Most men on the management boards are financiers, so they aren’t flexible enough to accept these changes.

Women, unfortunately, are still hidden behind men, they're afraid to suggest some new ideas. Men's leadership is so strong that sometimes women don't want to go forward, as they're afraid of being criticized or mocked. The surroundings change, but the logistics industry doesn't."

Weakness resulting from the wastage of women's leadership competences

Exclusion of female leaders and managers and lack of their involvement in the strategic decision-making processes (related to finances or major company changes) prevents full utilization of their managerial potential. This, in turn, restricts the growth of an organization, or even blocks it completely. We talk here about effective utilization of the competences characteristic for the female leadership.

According to our research respondents, these competences, which could be much better utilized in business organizations, include: intuitiveness, empathy, analytical skills, adaptability (flexibility), relationality, and, most of all, multitasking skills. The respondents believe that, in order to fully exploit these skills and competences, profound changes in thinking about women's leadership are required. Business must understand that soft skills are not a weakness but a strength of modern organizations! This opinion was clearly expressed in our interviews.

And so, in Case 1 the interviewed manager answered straight: "Women are often accused of being empathetic, which for many organizations isn't a leader's quality. But it is empathy that can help us to teach people how to read certain signals. Unfortunately, empathy is often ridiculed, some women even try to hide it." Similar opinion was presented also in other cases, e.g. in Case 12. The respondent said: "Flexibility, creativity and versatility, ability to find alternative solutions – women are able to predict and connect more things, which may be more effective than just going by the book. Companies often don't see this value, they don't pay attention, because following the procedures is much easier. It's a pity that often there's no space to really appreciate these women's competences." Finally, the respondent interviewed in Case 4 said that "Ability to cooperate and build relations – these are the main strengths of women and they could be better utilized by business."

As emphasized by our research respondents, inadequate utilization of women's competence potential in the leader and managerial positions is one of limiting factors for the growth of their business organizations, which results with their organizational cultures being insufficiently developed to respond to main challenges and requirements of the current trend of management by ESG. Moreover, in the period of competence deficiency, it is a huge waste. The companies which do not fully utilize available potential, very often developed at a cost of significant investment (into trainings and upskilling), waste not only the opportunity to benefit from a valuable resource – female leadership qualities – but also money.

Conclusions and discussion points

Below we present the conclusions from the analysis of the answers to the research questions.

RQ1: What are the main strengths of governance at 3PL companies in supporting women's leadership?

Our research confirms that, regardless of the type of business activity, the source of capital or the size, within the area of logistic processes the changes related to diversity & inclusion are being implemented in logistics organizations.

RQ2: What are the main weaknesses of governance at 3PL companies in the process of accepting women's leadership?

The main weaknesses of many 3PL organizations include:

- slow pace of implementation of the diversity & inclusion principles,
- restricting of the decision-making power of female leaders and managers, and so limiting their role to purely executive and not strategic,
- discrimination and/ or wastage of the leadership competences characteristic for women.

RQ3: What differences and similarities between 3PL companies and in-house logistics departments or logistics service providers for particular industry corporations occur in the process of including women managers into logistics and supply chain management?

The materials compiled during the interviews show a clear distinction between two groups of researched organizations in terms of changes related to equality of genders and development of women's leadership. The changes are significantly faster at in-house logistics departments or service providers for particular industry corporations than at the 3PL providers.

On the other hand, we noticed also certain similarities. These include stereotypical approach to women's roles in the managerial positions by the male members of management teams. We do not mean designing jobs in accordance with the specific roles attributed stereotypically to women (e.g. secretary or HR specialist) or men (e.g. CEO or manager), as our respondents did not describe such situations in their organizations. The real problem is caused by mental barriers, which significantly impede women's growth. These conclusions have been confirmed by our respondents. One of them, in Case 11 described it in the following way: "Women still hit the glass ceiling. Unfortunately, when it happens, they leave, because they don't have the freedom to act. In our company a woman doesn't have a chance to become a board member." And the respondent in Case 15 said: "There are a lot of women, but they're middle managers. This is related to the results, as for men only the results matter. If the organizations started looking at their business in a different way, more long-term, they'd have more women, because they'd understand growth differently and let the women on the management boards."

Limitations and future research

While this study contributes to the diversity and inclusion company governance theoretically and managerially it has limitations. Since this study was conducted in the context of the experience of Polish logistics service companies of various types, care should be taken in generalizing the results in other contexts such as different countries and national policies. The results of this study therefore should be re-examined in other contexts to generalize from our findings.

In addition, our empirical results regarding the strengths and weaknesses of different types of logistics service providers were somewhat different from our expectations. However, the conceptual framework of our research did not reveal why there some differences between in-house logistics departments and logistics service providers and external 3PL companies. This research will be extended in future by examining the reasons for cases of discrimination of women managers within the corporate governance structures.

We cannot explicitly state that the negative situations described in the interviews represent any specific trend, they rather show the slow pace of changes related to women's leadership. These changes occur, though, and the negative behaviors are not the result of intentional action, but of mental issues, which require more time, maybe even a change of generations. Business organizations should strive to create work environments which will shape desired attitudes and behaviors, such as openness, mutual respect, listening skills and awareness of the common goal. The question of proper management and full utilization of the competence potential remains the topic of a general debate, necessary for the logistics industry to understand its growth opportunities and benefits resulting from the potential of managerial competences, characteristic both for men and for women.

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SUSTAINABLE PACKAGING PROCESS PLANNING USING A VALUE STREAM MAPPING APPROACH

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Introduction

Since the beginning of commercial polymer production in the 1950s until 2015 a total of 6,300 million tons of plastic waste were generated worldwide, of which 9 % was recycled, 12 % incinerated and the remainder mostly either transferred to controlled landfills or unsupervised areas (Geyer, Jambeck and Law, 2017). The polymer foam material expanded polystyrene (EPS) faces the same end-of-life options. Expanded polystyrene, also referred to under the trade name Styrofoam, is commonly found in everyday packaging materials, such as food and beverage containers, packing ‘peanuts’ and cool boxes. Most often this is used once and then discarded. Even though it is possible to recycle the packaging material through mechanical or chemical processing (Lynwood, 2014), the effects that extraction of raw material, manufacturing, and improperly managed waste have on the environment should not be neglected. To address these concerns, scientists have been researching new alternative materials with a focus on environmentally friendly manufacturing methods and biodegradability. For this purpose, fungi have shown great potential, more specifically the mycelium which is the root system of single fungal threads (hyphae) outside the fruiting body (mushroom) (Bresinsky, 2021). Recently, mycelium bioengineering applications have been gaining traction in diverse areas such as textiles, furniture, automotive, construction, as well as packaging (Meyer et al., 2020). For the latter application, bio-composites made from agricultural or forestry by-products in combination with mycelium have proved to be good bio-derived replacements for petroleum-based expanded polystyrene and are produced by modifying the mushroom cultivation process. Mushroom growing has been researched by scientists for many decades, with Stamets (1993) in particular, providing an in-depth and extensive guide on this topic. Several research institutions and businesses developed fabrication methods for mycelium composites, for example Elsacker et al. (2020) published a framework on production processes and variables. Mycelium composites comprise all natural ingredients and are biodegradable, non-toxic, lightweight, water resistant, fireproof, non-abrasive, and cushioning (Elsacker et al., 2019; Sydor et al., 2022).

Inspired by these publications and by carrying out their own research and development, the start-up Fungarium has created a new production system. Its vision is to provide consumers with customisable, biodegradable, and carbon-neutral packaging solutions by combining bio-based materials with novel technologies. Once used, the products can simply be composted, giving back nutrients to nature which closes the loop from a linear to a circular economy. With the additionally created value of fertilisation, the fungal-based material is a multi-purpose product that results in almost zero waste. The focus of this study lies in identifying the essential planning parameters and process flows for the design of mycelium composite production systems.

Methodology

To design and plan production systems, the value stream mapping method was chosen as it is one of the most rapid and practical production planning tools for depicting material and information flows between processes. Two flowchart types are used: value stream analysis (VSA) and value stream design (VSD), referring respectively to the present-day production and the planned future outlook (Hartmann et al., 2018). The term ‘value’ signals that the final product has an added value given by its fabrication processes, while ‘stream’ symbolises the movement of material from one production step to the next (Erlach, 2013). The value stream symbols created by Rother and Shook (2003) are widely established as a common industrial ‘language’ and used for the VSA and VSD in this paper. To map the current value stream, we analysed the bio-fabrication method of mycelium composites including production resources (materials, tools, and equipment), as well as their initial set-up. Furthermore, the maximum production volume was also estimated. The first project phase of the start-up is coined ‘Fungarium 1.0’ which concerns itself with manual prototype production. Building on this, a concept for

future automated mycelium composite production is referred to as 'Fungarium X.0'. With the completion of these steps, all necessary information was collected. Using Microsoft Visio, the VSA for Fungarium 1.0 and the VSD for Fungarium X.0 were created.

Results

Production process

Fungarium has developed its own biomanufacturing system for mycelium composites that consists of six main processes: preparation of initial growth cultures, generation of grain spawn, preparation of substrate, pre-growth, moulding, and post-processing. Firstly, fungal spores are cloned in a glass jar (500 ml) containing a liquid culture (Fig. 1a). A small piece of mushroom 'flesh' (e.g. Oyster mushroom *Pleurotus ostreatus*) is placed into the nutritious substance, in which the spores then germinate and hyphae grow to form the mycelium network. This process takes three weeks to one month. Secondly, grains are wetted and sterilised before injecting a small amount of the mushroom culture into them. Approximately 70 grain jars can be inoculated from one liquid culture jar. The spreading of the mycelium and full colonisation of the grain spawn (Fig. 1b) takes about two weeks. In the third process step, the substrate (e.g. straw or woodchips) is wetted to open pores, making it more open to heat. Next, it is spread out on a drying surface and left to air-dry for 8 hours until excess water is drained out. The moist mass is filled into heatresistant plastic bags or buckets and placed into an autoclave for 18-hour sterilisation. Then they are taken out to cool down to room temperature, which takes 8 hours. In the pre-growth stage, the grains interwoven by mycelial networks are crumbled up into smaller fragments and transferred into the substrate bags or buckets. Then the containers are closed and shaken to obtain a homogeneous mixture before storing them in a tent with controlled temperature and humidity. The mycelium colonises the substrate by digesting the feedstock which is rich in lignin, cellulose, and hemicellulose (Elsacker et al., 2020). The incubation time is two weeks. At this stage, the mycelium has expanded and connected single fibres to small lumps, but the substrate is still predominantly loose. The colonised substrate mixture is pressed into plastic moulds and sealed. By storing them under regulated climate conditions, the mycelium grows further throughout the substrate, taking shape of the mould and hardening. Afterwards, the bio-composites are carefully removed from the form with a knife (Fig. 1c). The moulding process takes up to three weeks, depending on the selected fungal species. In the final post-processing step, the blocks are oven dried for one hour to kill the living mycelium. Hence a biodegradable but similar product to Styrofoam with respect to material properties and optics is thus created (Fig. 1d).

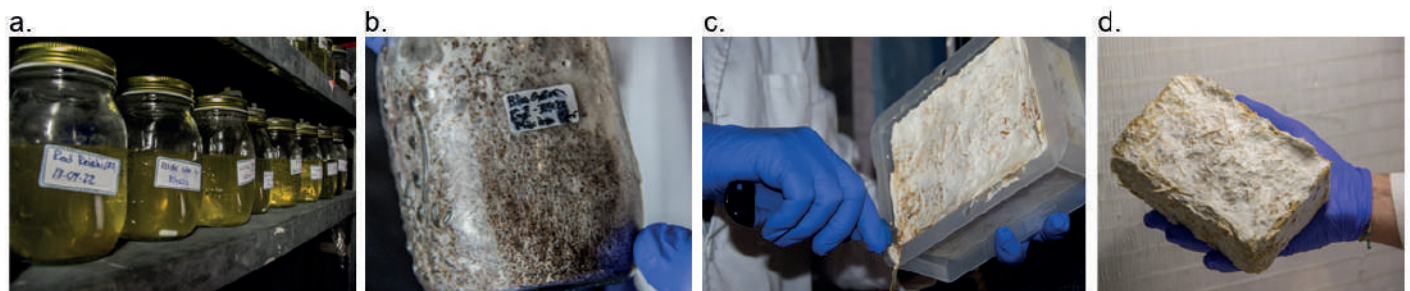


Fig. 1 Different stages of mycelium composite fabrication at Fungarium, a. mycelium grown in jars with liquid culture, b. inoculated grains, c. block removal from mould, d. finished mycelium composite block (Photo: Fixel, 2022)

Traditional production set-up

Currently at Fungarium there are three grow-tents (240 cm × 120 cm × 200 cm) built up in an open floor workspace. The indoor climate is regulated by simple sensors for humidity and temperature, a humidifier and heating fans regulate inner tent conditions. The first tent functions as a small laboratory. The designated storage space for liquid cultures fits about 20 jars. For grain sterilisation, an autoclave is utilised which can hold up to 30 litres (12 jars). Afterwards, the grain spawns are stowed inside the tent (maximum of 30 jars). The previously hydrated mass is spread out on a drying surface to eliminate excess of water. Then the raw material is packed into bags or buckets to be placed in an autoclave which can hold up to 100 litres. This equals a loading capacity of either 20 bags of 1.5 kg or 6 buckets of 35 kg substrate. The sterilised feedstock is transferred to the tents by hand or on trolleys. The other two tents feature three metal racks each to hold substrates and moulds. One storage rack has five divisions with a surface area of 1 m × 0.5 m. The limited space inside the tents gives the restriction for production quantity. Per division 6 bags or 3 buckets can be stored, assuming full production

this equals 90 bags or 45 buckets per tent for the pre-growth of substrates. For the production simulation, two standardised mould sizes are used: block (48.5 cm × 30.6 cm × 9.2 cm) and tray (36.2 cm × 29.2 cm × 8.4 cm). Each shelf fits 2 blocks or 4 trays, with 15 shelf compartments per tent this would result in a maximum inventory capacity of 30 blocks or 60 trays.

Concept of automated production

For mycelium products to eventually compete with mass-produced Styrofoam, shifting from manual to automated production systems is vital to generate more and faster output. Fungarium X.0 describes a future outlook of an automated factory design using advanced technologies and machinery. The large-scale production transitions from small units (liquid culture jars, substrate bags and buckets) to bulk sizes (large liquid culture tanks and substrate containers) that allow for standardized, automated logistics handling (conveyor belts, stacker cranes etc.). The manufacturing process transforms biowaste into mycelium mega-blocks by using industrial machinery such as shredders, presses, assembly line ovens, and mixers. Fungarium plans to operate a hybrid model with a branched production generating three value streams: moulding, computer numeric control (CNC) milling and polylactic acid (PLA) bags. The idea is to mass-produce mycelium substrate mixtures to fill large containers which are then processed into the required packaging products. For more product variety, customisable moulds are needed. With 3D printers, individual shapes can be made. Alternatively, the use of CNC milling machines can be explored to get the desired form of the end-product from a mycelium composite block. In the last product line biodegradable PLA bags are filled with crushed mycelium composites to have a similar functionality to Styrofoam packing peanuts to cushion delivery items.

Value stream analysis

With the processing times and inventory numbers listed in prior sections a value stream analysis for Fungarium 1.0 as shown in Fig. 2 can be created in accordance with the guidelines by Rother and Shook (2003).

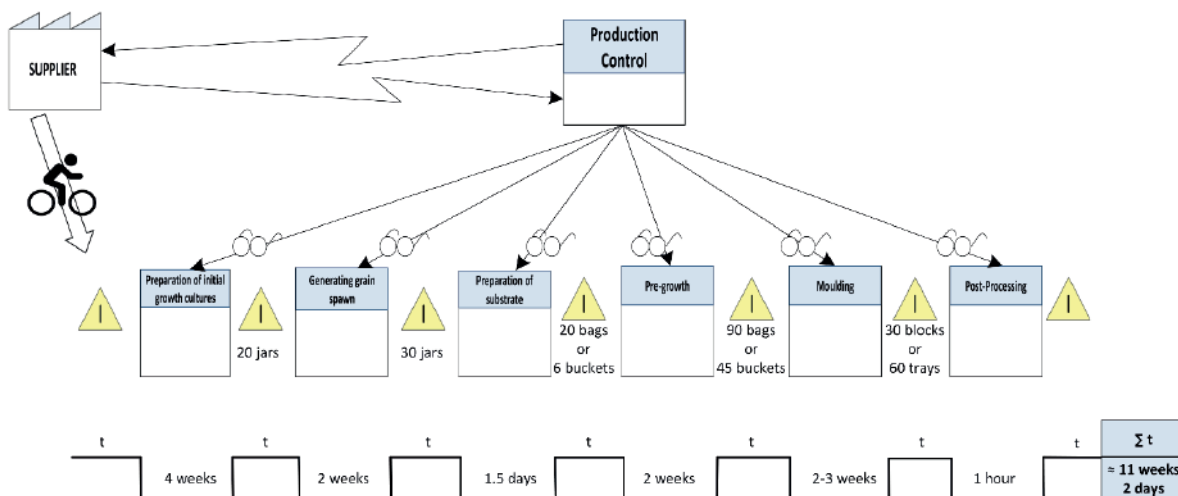


Fig. 2 Value stream analysis of Fungarium 1.0

The six process boxes are analogous to the previously described manufacturing steps: preparation of initial growth cultures, generating grain spawn, preparation of substrates, pre-growth, moulding, and post-processing. The triangles represent inventory between processes, i.e. work-in-process (WIP). The number of items is listed underneath, assuming full production and maximum inventory occupancy. The zigzag-arrows signal the electronic information flow between supplier and Fungarium. Currently, raw materials are picked up by cargo bike. The thin straight arrows indicate the manual information flow between workstations. The glasses icons symbolise the 'go and see' principle which means that information is gathered manually, e.g. the worker checks if the humidifiers are still working properly. The timeline illustrates product lead time and is subdivided into value-adding and non-value-adding time. In total the production cycle of mycelium composites takes approximately 11 weeks and 2 days. Waiting time between manufacturing steps, indicated with the placeholder 't', does not contribute any value but might significantly weigh in total production time. It is yet to be determined by tracking time between the end of one process and the beginning of the consecutive process which includes transportation between workstations and calculating averages. Therefore, exact total throughput time remains unknown.

Value stream design

The VSD shown in Fig. 3 depicts how an optimised production system in the future could look (Fungarium X.0).

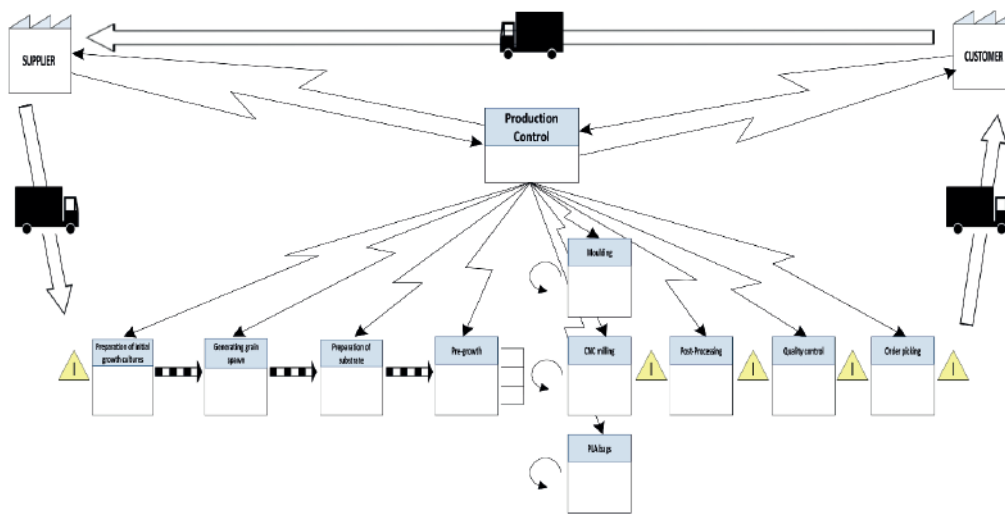


Fig. 3 Value stream design of Fungarium X.0

Inbound and outbound logistics are carried out by electric trucks. Input raw material is supplied by farmers, packaging products are delivered to customers and packaging waste is recollected for agricultural soil remediation. All workstations are equipped with computers to enable electronic communication and information exchange. Smart sensors are installed that make environmental data available to workers at all times and eliminate the 'go and see' principle. The striped arrows signal the 'push' movement of materials within the first part of production which are then stored as WIPs in a supermarket system (Rother and Shook, 2003). This means that mycelium mixtures are mass-produced up to the point of pre-growth. Connecting the processes with conveyor belts allows for continuous flow manufacturing instead of isolated workstations with inbetween manual material transport. For the second part, production is split into three lines that draw material from the supermarket. In the moulding and CNC milling value streams mass customisation is aimed for and products are manufactured upon customer inquiry, whilst the PLA bags are standardised goods and produced in high quantities to keep an ample stock. The former follows a make-to-order and the latter make-to-stock system (Zaerpour et al., 2008). Afterwards, the mycelium products go to post-processing and quality inspection. Lastly, finished goods are stored in warehouses before packing and shipping.

Discussion

In the first project phase, Fungarium 1.0, samples are produced in a small setting with three tents and self-built equipment, in some cases this represents the current status of commercial production, some companies have an augmented production of the same process. In the creation of the VSA, two main issues were identified, lengthy processes and limited inventory capacity. All production steps are carried out manually and thus dependent on manpower which hinders fast output. Another obstacle to ramping up production volumes are the biological methods. The slow incubation and growth processes take two to four weeks each. With the given volume capacity of tents a restricted amount of work-in-processes can be handled at a time and incoming materials pile up. The moulding process is also constraining efficient material flow - one mould results in one end-product. Larger batch sizes would require the equivalent number of moulds for simultaneous fabrication. With a smaller quantity the production process has to be repeated multiple times reusing the shapes. The former way requires many moulds and inventory space, whilst the latter prolongs lead time. Furthermore, inefficient equipment limits throughput. The self-built grain- and substrate autoclaves work slowly and are very restricted in volume capacity so that only a small amount of material can be sterilised at once. These issues show the limited scalability of batch mycelium composite fabrication using grow-tents and the moulding technique. Although bigger amounts could be treated with investment in machinery, there is no innovation on the overall process.

For packaging products, which are quickly consumed, long throughput times are disadvantageous. A way to accelerate processes and reduce the manufacturing cycle time needs to be found. Fungarium X.0 represents a possible solution for mass production of mycelium composites which necessitates novel production processes using high-functioning, industrial-scale machinery. In the next R&D phase, applied research will be conducted, i.e. collaborating with other firms and research institutions to test and develop upscaled production systems. Cross-industry and cross-sector projects help to investigate the integration of biotechnological and industrial processes, and to model production lines into a scalable and fully autonomous manufacturing system.

The described process flows were visualised with a value stream analysis and a value stream design which depict production steps with respective times and material flows, as well as show proof of concept for potential investors and collaborators. There are, however, certain limitations and disadvantages. The value stream method only shows an overall picture of manufacturing processes, as adding every single activity would look cluttered in a two-dimensional format. Layout and organisation of resources are not depicted. An improved method of illustrating production is by means of simulation. The software FlexSim (by FlexSim Software Products, Inc.) or Tecnomatix Plant Simulation (by Siemens AG) can be used. They offer more functionalities with 3D-modelling of machinery, material quantities, and workers in a running simulation of production processes.

Conclusion

Styrofoam as a low cost, mass-produced packaging material is hard to beat. Fungarium is working to provide a viable alternative by using non-toxic and biodegradable mycelium-based packaging. To compete, the creation of a mass production but low cost system for mycelium composites is imperative. This paper outlined the production procedures and equipment to fabricate moulded mycelium composites at small scale. The design requirements for the production set-up were specified. The findings of process flow assessment indicated many considerable weak points in slow processes, space restrictions, and inefficient equipment. A concept for mass production was drafted that is driven by the incorporation of advanced technologies and machinery. Industry collaborations will enable testing of industrial machinery that mark the transition from prototyping in a small setting to high-volume production in a mega factory. The presented design and conceptualisation stages of mycelium composite production act as guidance for further product development and process optimisation. Capturing manufacturing processes, resource planning, and forecasting of production volumes form the basis for controlling and monitoring future operations. Fungarium's slogan "wrapped in nature" is reflected in its circular-economy based strategy: organic waste is taken from the ecosystem, processed in a resource-conserving production system, and at the end given back to nature to preserve it for future generations.

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ADDITIVE MANUFACTURING IN PHARMACEUTICAL SUPPLY CHAIN

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Introduction

AM, commonly called 3D printing, creates objects by layering materials based on 3D model data (ASTM F2792-12, 2012). Over the years, 3D printing technology has made remarkable advancements and has found numerous applications in the field of medicine. These applications include the production of implants, instruments, preoperative models, and tools (Tuomi et al., 2014). 3D printing technology offers a wide range of advantages to the healthcare industry, including the ability to produce low-volume, highly variable products, flexibility in manufacturing, customization capabilities, and the ability to create complex geometric designs, all at a relatively lower cost (Pucci et al., 2017; Ryan et al., 2016; Thawani et al., 2016). Traditional manufacturing methods might be cumbersome and expensive for producing clinical gadgets and personal protective equipment (PPE). In contrast, AM might be well-suited for producing such customized products (Patel & Gohil, 2021). Additionally, the use of 3D printing can allow quick design iterations and revisions, reducing both cost and time, which helps address parts shortages and supply chain limitations (Javaid et al., 2020). Hence, integrating 3D printing technology into the healthcare process could bring numerous benefits and carries significant implications for PSCs, as shown in Table 1.

Applications	Benefits
AM presents significant opportunities for the pharmaceutical industry to address challenges in traditional SCs.	By leveraging the capabilities of 3D printing, pharmaceutical companies can improve manufacturing efficiency, produce personalized medications, enhance drug delivery systems, accelerate drug development, and foster innovation.
3D printing enables the fabrication of complex geometries and customized drug release profiles tailored to individual patients (Englezos et al., 2023).	This personalized approach improves patient compliance, enhances treatment outcomes, and reduces the risk of adverse drug reactions.
The rapid prototyping capabilities of 3D printing allow pharmaceutical companies to quickly iterate and refine their product designs (Gibson, 2006).	This accelerates the development process by reducing the time and cost associated with traditional manufacturing methods. It enables more efficient testing of different formulations and drug delivery mechanisms before large-scale production.
manufacturing of pharmaceutical products, eliminating the need for extensive warehousing and reducing inventory costs (Wang et al., 2023).	This can be particularly advantageous for rare or orphan drugs, where demand fluctuates, and stockpiling is not economically viable. Additionally, it allows for decentralized manufacturing, enabling production closer to the point of care, which can improve supply chain resilience and responsiveness (Verboeket et al., 2021).
Traditional pharmaceutical manufacturing often generates significant waste due to the need for mass production and overstocking. 3D printing, on the other hand, allows for precise and efficient use of materials, reducing waste and minimizing the environmental impact of production.	The localized manufacturing made possible by 3D printing can help reduce the carbon footprint associated with long-distance transportation (Holmström, 2022).

Table 1: Applications and Benefits of 3D Printing in Pharmaceutical Supply Chains

In summary, using 3D printing technology in PSCs demonstrates the vast potential for enhancing efficiency and effectiveness. With ongoing advancements in 3D printing technology, its adoption within the medical sector is expected to grow, leading to improved patient outcomes and a more resilient and efficient medical supply chain (Wang et al., 2023).

While the existing literature extensively explores the use of AM in PSC from different perspectives, there is a notable scarcity of studies examining the interrelationships between these perspectives. Our paper conducts a comprehensive literature review that explores AM's potential benefits and applications in PSC and elucidates their interconnectedness. To guide our investigation, we have formulated the following review question (RQ):

RQ: To what extent can 3D printing technology impact the medical supply chain?

The study determined that 3D printing influences the SC through three primary avenues: reducing complexity, bringing manufacturing facilities closer to end users, and shifting production from make-to-stock to make-to-order. These changes affect inventory levels, subsequently affecting SC sustainability, efficiency, responsiveness, and resilience. Simplified SC and localized production changes directly impact sustainability, efficiency, responsiveness, and resilience. However, the challenges of implementing 3D printing in the medical SC are moderating factors in these cause-effect relationships, altering the effects on dependent variables.

This research contributes to knowledge by proposing a conceptual framework representing the interconnectedness between different factors within the medical supply chain influenced by 3D printing technology. The framework elucidates the impact of supply chain modifications on its overall effectiveness, offering a straightforward and easily comprehensible approach to grasping these relationships.

Literature review

In a traditional SC, raw materials are typically supplied from suppliers, manufacturing takes place in factories, and the finished products are subsequently transported to distribution centres for delivery to retailers and, ultimately, to end consumers for purchase. However, implementing 3D printing technology can simplify the SC by reducing the number of entities involved in the chain and the overall production volume (Oettmeier & Hofmann, 2016b). In a 3D printing SC, the process involves 3D model providers who send the 3D printing file to facilities based on demand, adopting a just-in-time strategy for supplier material procurement. Subsequently, once the products are completed, they are directly delivered to consumers (Kubá & Kodym, 2017). Furthermore, incorporating 3D printing decreases lead time by streamlining the distribution network (Nazir et al., 2021).

Utilizing 3D printing in pharmaceutical manufacturing offers numerous benefits. One notable advantage is the reduction in SC relocation, as hospitals can directly produce medical equipment and components instead of relying on sourcing from other regions (Choudhary et al., 2021). Researchers have examined the impact of AM and decentralization on the performance of SCs by conducting simulations and comparing three scenarios: the conventional SC, centralized additive SC, and decentralized additive SC. The study's findings indicate that the centralized additive SC enhances responsiveness and available capacity compared to the traditional SC. On the other hand, the decentralized additive SC yields improved and more accurate responses, resulting in reduced response times (Nuñez Rodriguez et al., 2022). While centralized SCs for medical equipment production carry risks due to potential disruptions, adopting AM presents an opportunity for localized production and increased resilience of SCs (Verboeket et al., 2021; Kamble et al., 2023).

In a study conducted by Rejeski et al. (2018), the authors emphasize the capability of AM to produce small quantities, eliminating the need for a surplus inventory that is commonly associated with traditional manufacturing processes relying on economically viable batch concepts. This shift in production methodology transforms the SC by enabling on-demand manufacturing and supporting the implementation of just-in-time practices. Compared to traditional manufacturing methods, 3D printing technology has the potential to reduce waste by precisely producing specific products when they are needed, based on customer demand. This approach helps in reducing the inventory stored in warehouses.

In a study by (Weaver et al., 2022), the pharmaceutical industry has a significant environmental impact, with 52 million metric tons of CO₂ equivalent (MMt-CO₂e) produced in 2018. However, using AM and microfluidics offers environmentally friendly and economically viable methods for pharmaceutical manufacturing. Specifically, by incorporating 3D printing technology, the consumption of materials such as solvents can be reduced, leading to potential environmental benefits. For instance,

according to Kellens et al. (2017) the widespread implementation of AM in diverse industries can decrease annual CO₂ emissions by 328 metric tonnes.

As (Kunovjanek & Wankmüller, 2020) highlighted, AM plays a vital role as a contingency plan, offering high adaptability and flexibility to enhance process stability and strengthen organizational resilience during times of crisis when conventional manufacturing and supply methods prove insufficient. However, when supply chains heavily depend on "lean manufacturing" and "just-in-time" systems to minimize inventory costs, they can be vulnerable to sudden disruptions, particularly when shipping involves multiple countries (Singh et al., 2021).

Though its numerous benefits, utilizing 3D printing in PSCs also presents notable challenges that require attention. These challenges can be categorized into 14 key areas, including time-consuming processes, material scarcity, cost issues, limitations of technology, inadequate education and training for designers and workers, coordination difficulties, complex production processes, machine malfunctions, resistance from workers towards adopting new technology, shortage of skilled workers, the threat of inventory obsolescence, issues with standardization, concerns about quality control, and the need for infection prevention measures (Wenqi et al., 2024). By understanding and addressing these challenges, the pharmaceutical industry can optimize the implementation of 3D printing in supply chains, enhancing overall efficiency and effectiveness.

Methodology

This paper utilizes a Systematic Literature Review (SLR) approach that integrates and examines existing studies in the field to establish research frameworks for guiding practitioners and researchers (Denyer & Tranfield, 2009). The SLR process encompasses three key stages: planning, conducting, and reporting the review (Kitchenham, 2007). During the planning stage, the researcher determines the purpose of the review, formulates research questions, and develops a review protocol. In the conducting stage, the researcher applies inclusion and exclusion criteria to select relevant papers, subsequently extracting, analyzing, and synthesizing data. Finally, in the reporting stage, the researcher presents a report detailing the findings of the literature review (Xiao & Watson, 2019).

Findings and Discussion

Our research findings indicate that using 3D printing technology in PSCs can lead to streamlined processes, localized production, and a shift from a push strategy to a pull strategy as shown in Figure 1 (Oettmeier & Hofmann, 2016a; Verboeket et al., 2021; Durach et al., 2017). These advantages collectively contribute to the reduction of inventory levels. By simplifying the SC with fewer nodes and lower production volume, efficiency, and resiliency are enhanced while minimizing inventory levels. Furthermore, localizing production shortens the distance between manufacturers and consumers (Kubá & Kodym, 2017), thereby improving SC responsiveness (Nazir et al., 2021). Additionally, the adoption of 3D printing technology enables the transition from a push to a pull strategy, further aiding in inventory reduction (Durach et al., 2017).

The decrease in inventory levels has significant implications for SC sustainability, efficiency, responsiveness, and resilience. A lower inventory level contributes to reduced waste in the SC, promoting sustainability. From an efficiency and responsiveness standpoint, lower inventory levels decrease holding costs, although it may reduce responsiveness during shortages. Conversely, higher inventory levels can enhance responsiveness but carry the risk of overstocking. Regarding resilience, lower inventory levels help mitigate the risks associated with overstocking. However, lower inventory levels may decrease resilience in the face of shortages or unexpected events. Thus, striking a balance between inventory levels and the SC's sustainability, efficiency, responsiveness, and resilience is crucial.

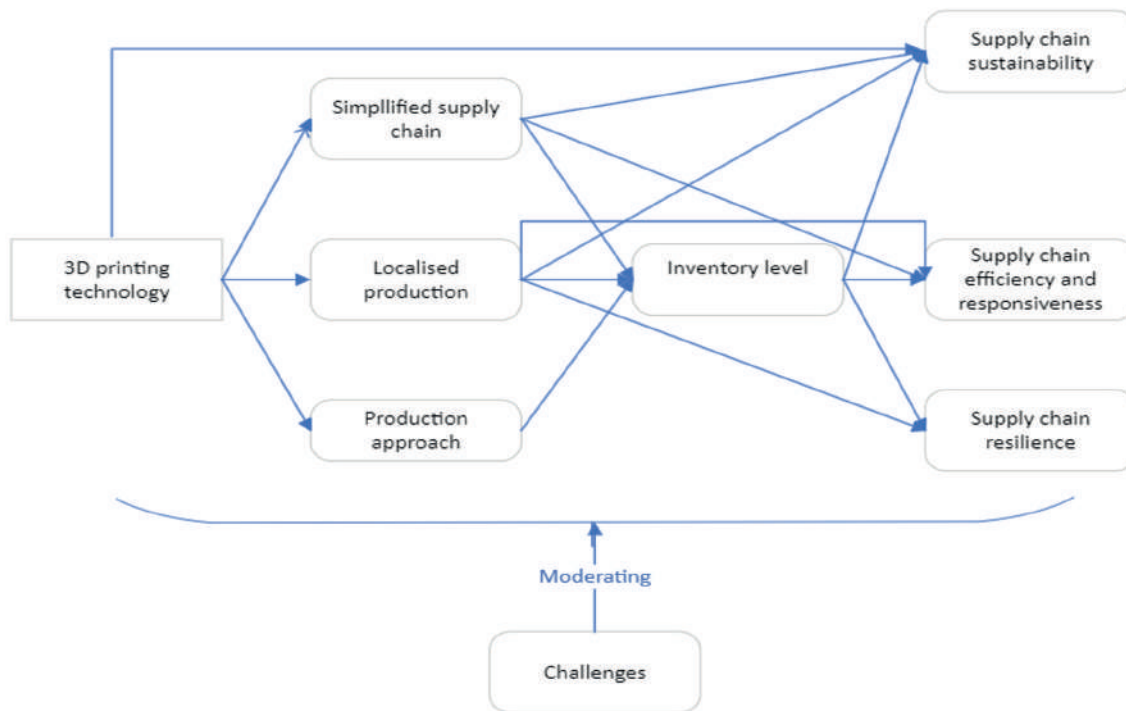


Figure 1: 3DP influence on PSC

Figure 1 summarizes the impact of AM on PSCs, highlighting its influence on sustainability, efficiency, responsiveness, and resilience. Considering these findings, it is recommended that future research focuses on investigating the effects of 3D printing on the design of medical SC networks. By conducting simulations of various scenarios, the performance of a centralized SC can be compared to that of a localized supply chain incorporating 3D printing, with a specific focus on resilience and sustainability. While some studies have explored the combination of traditional manufacturing and additive manufacturing, there is a lack of research, specifically within the medical SC context, considering resilience and sustainability aspects. Therefore, it would be valuable to examine whether a localized SC with 3D printing could enhance resilience capacity while also considering the associated trade-offs. Furthermore, while several papers during the COVID-19 pandemic have suggested that 3D printing in a localized SC can improve resilience, few have delved into the potential cost implications. Hence, future research could employ different scenarios to determine the feasibility of additive manufacturing in the medical industry. We propose several propositions that can be empirically tested using relevant data:

Proposition 1: The utilization of 3D printing technology has the potential to streamline the PSC, resulting in improved sustainability, efficiency, and responsiveness.

Proposition 2: Implementing a redistributed manufacturing PSC with 3D printing will reduce inventory levels compared to a centralized SC model.

Proposition 3: A redistributed manufacturing supply chain incorporating 3D printing enhances the resilience of the SC when compared to a centralized manufacturing SC.

Conclusion

In recent years, AM has become increasingly significant in the medical industry, and the COVID-19 pandemic has further highlighted its potential to address SC disruptions by enabling the relocation of manufacturing facilities closer to end customers. This adaptability allows for a more responsive approach to unpredictable demand while maintaining reduced inventory levels, which can be critical in the medical field. Consequently, research publications focusing on AM in the medical industry have noticed a noticeable increase since 2018.

This study identifies three primary effects of 3D printing on the supply chain: simplifying processes, localization of manufacturing facilities, and shifting from make-to-stock to make-to-order production. These changes directly affect inventory levels, significantly impacting the supply chain's sustainability, efficiency, responsiveness, and resilience.

This study offers two significant contributions. The first contribution is of a theoretical nature. It presents a conceptual framework that visually represents the interconnectedness between different variables within the medical supply chain influenced by 3D printing technology. By elucidating how changes in the supply chain impact its performance, the framework offers a clear and intuitive approach to comprehending these relationships. The second contribution is practical in nature. The findings of this study have potential benefits for the medical industry, additive manufacturing industry, and researchers. The medical industry can consider leveraging 3D printing to produce essential spare parts to address fluctuating demands effectively. The additive manufacturing industry can promote the use of 3D printing technology in other sectors by highlighting its ability to enhance supply chain performance. For researchers, this study provides valuable insights and directions for further research.

Overall, the integration of 3D printing technology in the medical industry and its effects on the SC have the potential to revolutionize production processes, improve SC performance, and deliver more responsive and sustainable healthcare solutions.

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KEY PERFORMANCE INDICATORS FOR THE SUSTAINABILITY EVALUATION OF FREEPORTS

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1. Introduction

Freeports are a series of government-assigned special economic zones (SEZs) usually located around seaports or airports where different customs rules are applied to boost trade, jobs, and investment across the region. Today, similar supervised special zones exist widely worldwide (3,500 estimated), although the adopted concepts are not necessarily identical across countries (Johansson and Nilsson, 1997). The diversified concepts within the context include free zone, export processing zone, free trade zone, free port, free trade port, and free trade port zone. Table 1 shows the distinctions between different SEZs (The World Bank, 2008). Although the concepts and policies are different, the functions of SEZs are usually defined as key areas for economic development and powerful centres for work production, raw material importation, and product exportation.

Type	Objective	Size	Typical location	Typical Activities	Markets
Export Processing Zone	Export manufacturing	<100 hectares	None	Manufacturing, processing	Mostly export
Free Trade Zone	Support trade	<50 hectares	Port of entry	Transit and trade-related	Domestic
Freeport	Integrated development	>100 km ²	None	Multi-use	Internal, domestic, export

Table 1. Distinctions between types of SEZs (The World Bank, 2008)

Despite offering numerous advantages, the implementation of freeports presents practical challenges. There is ample evidence that freeports tend to face various common risks of criminal exploitation (RUSI, Centre for Financial Crime and Security Studies, 2020; Daniel, 2020; Davidson, 2008). In addition, evidence from freeports in other countries reveals that lax application processes, weak regulations, inadequate enforcement, and opaque customs processes have resulted in severe environmental degradation (Wildlife and Countryside Link, July 2020). It is necessary to develop a new methodology aiming at freeports, which enables the incorporation of sustainability into their overall development goals and policies. In recent decades, sustainability has attracted much attention from both the academic and industrial sectors. The most widely accepted definition of sustainability is the development that satisfies present needs without compromising the ability of future generations to meet their own needs (WCED, 1987). Research on the sustainability of ports and maritime logistics is rising over recent years (Sung-Ho et al., 2018). However, no one has addressed the significance of evaluating and benchmarking sustainable freeport development in coping with various emerging challenges such as climate change and economic upheavals.

This paper aims to identify and evaluate key performance indicators (KPIs) influencing the sustainability of freeports. To achieve this aim, it first reviews and analyses the sustainability indexes used in freeports, ports, and port cities in the existing literature. Then, it combines the literature review, freeport proposals, and experts' opinions to identify KPIs for measuring freeport sustainability. Finally, it collects expert questionnaires for rating the importance of the identified KPIs from multiple stakeholders' perspectives. The rest of the paper is structured as follows. Section 2 summarises the literature review. Section 3 introduces the methodology of this study. Section 4 provides an analysis and discussion of the results. Section 5 concludes the paper.

2. Literature review

At present, studies on freeports mainly focus on their functions, policies, and management system, with few conducted on performance evaluation indexes. Chen et al. (2018) evaluated the development performance of China's free trade port zones. Wang et al. (2019) conducted an efficiency evaluation of Shanghai Port, Singapore Port, and Busan Port. Huang et al. (2020) evaluated the service quality of the free trade port zone. Liu et al. (2021b) analysed port efficiency with economic and operational factors in six Pilot Free Trade Zones in China. Some indicators were commonly employed in these studies such as the development area of freeports, information technology, tax policy, the efficiency of customs clearance, and logistics services. It reveals that current studies on the performance evaluation of freeports have primarily focused on the economic perspective. However, from the well-established concept of sustainability and the sustainability evaluation works in other relevant sectors (e.g., ports), sustainability is beyond economic development, concerning other issues such as environment and social responsibility. The assessment of freeport sustainability has therefore not been adequately addressed in the current literature, indicating the need for new approaches and solutions to address this research gap.

To gain a comprehensive understanding of sustainability KPIs from multiple dimensions, this study broadly searched the existing relevant literature in sustainable ports and port cities. Studies on port and/or port city sustainability evaluation have been increasing in the last decade, particularly from the environmental perspective. There are three certifications for improving environmental performance in ports, namely, ISO 14001, Green Ports, and Ecoports (Asgari et al., 2015). By adhering to these certifications, ports can improve their environmental performance by monitoring issues such as air and water pollution, noise pollution, energy consumption, efficient resource utilisation, waste management, and the adoption of clean technologies. However, the social aspect has been relatively overlooked in measuring port sustainability. The most commonly evaluated social indicators are job generation and number of injuries. Shiau and Chuang (2015) developed port sustainability indicators including four indicators associated with social equity, namely port facilities designed for older and disabled people, annual accident rate, annual fatalities, and annual injuries in a port area. Stankovi et al. (2021) compared 37 seaport regions in seven countries on the European side of the Mediterranean in various aspects of sustainability including 7 social indicators (i.e., life expectancy, population density, gender employment gap, fertility rates, lower secondary education and below, upper secondary education and above, participation in education and training).

Sustainability development is a complex and multidimensional issue, thus its evaluation requires a synthetic index (Bluszcz, 2016). The main synthetic indexes of sustainability include Ecological footprint, Environmental performance index, Sustainability society index, and Synthetic indicator of sustainable development (Laxe et al., 2017). Whereas these indexes are generally applied to countries, areas, or regions, and no synthetic index has been proposed to evaluate freeport sustainability. It becomes more difficult when concerning that the data supporting the KPIs at a micro freeport level suffers more uncertainty than the macro country or region level. An evidential illustration is that the economic statistics are often conducted and released at a country or region level, rather than the freeport. Hence, developing a new holistic framework to evaluate and benchmark freeport sustainability becomes necessary yet challenging. One of the key steps towards the framework development is to newly identify and weigh the importance of KPIs influencing freeport sustainability.

3. Methodology

3.1 The Global Reporting Initiative (GRI)

The GRI has established a sustainability framework that has been most widely utilised within the context of ports and port cities (Cavallo et al., 2015; Liu et al., 2021a; MacNeil et al., 2021; Majidi et al., 2021; Oh et al., 2018; Roh et al., 2021; Schipper et al., 2017; Shiau and Chuang, 2015; Stankovi et al., 2021). This framework proposes an index system from social, economic, and environmental dimensions based on a Triple Bottom Line (TBL) method. The TBL approach evaluates the business performance by considering the traditional bottom line of financial performance, i.e., net income, and two additional bottom lines that assess the impact of companies' social responsibility and environmental management, respectively (Roh et al., 2021). Compared to other established sustainability frameworks such as the Driving force-state-response and Pressure-state-response frameworks (Dai et al., 2013), Capital frameworks, System of integrated environmental and economic accounting framework, and Systems analytical framework, the GRI framework allows for comparisons among different organisations in multiple parallel sustainability dimensions. It takes advantage of flexible indicator sets and clear indicator categories, avoiding ambiguity and overlap among different indicator categories. Therefore, this study adopts the GRI hierarchical framework to identify KPIs influencing freeport sustainability.

3.2 KPI evaluation

This section outlines the two key steps of KPI evaluation as the followings:

Step 1: KPI identification. According to Chamaret et al. (2007), there are two main approaches to selecting indicators: the top-down and the bottom-up. The top-down approach involves identifying indicators from various types of literature such as publications, reports, and standards, and then refining them to create a final set of agreed indicators. On the other hand, the bottom-up approach involves compiling the final set of indicators based on the proposals of industrial stakeholders, who contribute their insights on relevant issues and the perceived significance of indicators. This study integrates both approaches to selecting effective KPIs for evaluating freeport sustainability. Furthermore, the verification of KPIs is conducted through expert interviews to ensure the relevance and comprehensiveness of the selected KPIs.

Step 2: KPI importance analysis. To evaluate the significance of KPIs, online survey is utilised to collect data from multiple freeport stakeholders including researchers who have related studies on freeport, policymakers, practitioners who are experts directly involved in the day-to-day operations and management of freeports, service users that make use of the infrastructure, incentives, and trade facilitation services offered by freeports (e.g., businesses, traders, importers, exporters, and manufacturers), and public residents. The survey of this research consists of two main parts. The first part aims to gather information about the experience and background of participants. The second part aims to evaluate the relative importance of KPIs using a Linkert scale method. Compared to other frequently used methods in criteria selection such as Analytic Hierarchy Process (AHP) (Saaty, 1980), Decision-Making Trial and Evaluation Laboratory (DEMATEL) (Gabus and Fontela, 1972), and PROMETHEE (Brans et al., 1982), the Linkert scale shows its competitive advantage as it is easy to understand and implement, thus particularly helpful when the research subject involves a large number of indicators and limited professionals. Researchers commonly use 5, 7, or 10-point scales to obtain importance ratings. The low end of the rating scale is typically noted as 'not important at all' and the high end of the scale is identified as 'extremely important' or 'very important' (Fontenot et al., 2007). This study uses 7-point scales (1=not important at all, 7=extremely important).

4. Results analysis and discussion

Table 2 presents the results derived from the above mentioned two steps regarding the hierarchy, references, arithmetic mean (AM) values of importance scores, and importance rankings of the finalised KPIs.

Step 1: KPI identification. The process of KPI identification involves KPI selection and verification. At first, 40 KPIs are chosen from the literature review, and 8 more KPIs are selected from freeport proposals, composing an index with 48 level-3 KPIs, 13 level-2 KPIs, and 3 top-level KPIs. Then, the KPIs from the first round are checked again with expert interviews to ensure their relevance and comprehensiveness. Consequently, 3 additional KPIs are suggested by experts (as shown in Table 2). 9 level-3 KPIs from the literature review are eliminated because they do not directly contribute to freeport development goals nor are they impacted by the freeport construction. The 9 eliminated KPIs include 4 economic KPIs (port infrastructure capacity, labour productivity, electricity cost, and fuel cost), 3 environmental KPIs (electricity consumption, fuel consumption, and contingency plans for pollution accidents), and 2 social KPIs (employment of collective bargaining agreement, employee retention rates). A level-2 KPI productivity and cost efficiency is eliminated along with its three sub-KPIs (labour productivity, electricity cost, and fuel cost). The refined index consists of 42 level-3 KPIs, 12 level-2 KPIs, and 3 level-1 KPIs.

Step 2: KPI importance analysis. Once the KPI framework is finalised, online survey is conducted via the Jisc platform for the importance analysis. 21 participants have completed the survey, of which 17 are selected as they possess relevant expertise in the subject area. These 17 respondents include 3 researchers, 3 policymakers, 4 senior practitioners, 3 service users, and 4 public residents, representing a diverse range of countries (i.e., The UK, China, Morocco, Germany, Russia, Dubai, Ghana, Canada, Brazil, and Iran) based on their knowledge of freeports.

Level 1	Level 2	Level 3	References	AM	Ranking
Economic	Freeport size	Development area of freeport	Liu et al., 2021a	5.59	10
		Port cargo tonnage	Pourebrahim and Mokhtar, 2016	5.65	9
		Port container throughput	Li et al., 2018	5.71	6
		Movement of rail freight in/out of the freeport	Freeport proposal	5.59	10
		Movement of road freight in/out of the freeport	Freeport proposal	5.76	5
	Freeport infrastructure	Number of new infrastructure projects	Freeport proposal	5.59	10
		Information technology	Huang et al., 2020	6.12	1
		Facility availability	Huang et al., 2020; Majidi et al., 2021	5.94	3
		Number of customs sites	Freeport proposal	5.12	25
		Number of tax sites	Freeport proposal	5.00	31
		Tax policy	Chen et al., 2018; Huang et al., 2020	5.82	4
	Service quality	Cargo traffic congestion	Expert interview	5.71	6
		The efficiency of customs clearance	Chen et al., 2018	6.12	1
		Diversity of logistics services	Chen et al., 2018	5.71	6
		Operational accuracy	Expert interview	5.41	15
Economic aggregate	GDP change rate	Pourebrahim and Mokhtar, 2016	4.18	42	
		GDP per capita	Pourebrahim and Mokhtar, 2016	4.41	40
		Total import and export of foreign trade change rate	Cerreta et al., 2020	5.12	25
		Foreign direct investment	Lukman et al., 2022	5.00	31
		Number of businesses operating at freeport development sites	Freeport proposal	5.47	14
Environmental	Environmental pollution	Air pollution	Papaefthimiou et al., 2016	5.24	17
		Water pollution	Jugovic et al., 2022	5.24	17
		Noise pollution	Castellano et al., 2020	4.82	37
		Soil pollution	Mora et al., 2005	5.12	25
	Waste management	Hazardous waste handling	Hua et al., 2020	5.29	16
		General waste management	Chiu et al., 2014	5.24	17
		Centralised sewage treatment	Li et al., 2018	5.06	29
	Energy and resource usage	Water consumption management	Chiu et al., 2014	5.00	31
		Clean energy sources	Jeevan et al., 2022	5.00	31

	Environmental protection	Environmental training	Munim et al., 2020	4.59	39
		Ecosystem and habitats protection	Castellano et al., 2020	5.18	23
		Climate change adaptation and mitigation	Burskyte et al., 2010	4.71	38
		Environmental protection policy	Expert interview	5.59	10
Social	Job generation	Number of new jobs due to the freeport development	Majidi et al., 2021	5.24	17
		Employment in high-tech and knowledge-oriented sectors	Pourebrahim and Mokhtar, 2016	5.24	17
	Workforce development and diversity	Gender equality	Stankovic et al., 2021	4.29	41
		Number of skill training	Roh et al., 2021	5.24	17
		Participation in skill training	Stankovic et al., 2021	5.12	25
	Safety and security	Fatal injuries	Roh et al., 2021	5.18	23
		Non-fatal injuries	Roh et al., 2021	5.06	29
		Cargo theft accidents	Freeport proposal	4.88	36
	Innovation and collaboration	The number of projects running jointly between firms and research innovation organisations within the Freeport area	Freeport proposal	4.94 Freeport proposal	35

Table 2. KPIs for freeport sustainability evaluation

At the lowest level of the hierarchy, the most significant KPIs are information technology and efficiency of customs clearance, both scoring 6.12. There are 13 KPIs ranked top 10, of which 12 are under the economic dimension, 1 belongs to the environmental dimension (environmental protection policy), while none falls within the social dimension. On the social dimension, the most important KPIs are the number of new jobs due to the freeport development, employment in high-tech and knowledge-oriented sectors, and the number of skill training, all ranking at 17th place.

Figure 1 illustrates the importance of level 2 KPIs, with service quality being the most important (5.74), followed by freeport size (5.66) and freeport infrastructure (5.60). At the 1st level of the index, the economic dimension has the highest importance score at 5.45, followed by the environmental dimension (5.08) and the social dimension (5.02). Moreover, Figure 2 presents a comparison of perceptions among different stakeholder groups. Policymakers and practitioners exhibit similar preferences, both prioritising the economic aspect, followed by the social and environmental aspects. Researchers and public residents demonstrate a preference for the environmental aspect first, followed by the economic and social aspects.

The results of this study share similarities with previous studies. As mentioned in the literature review, previous studies have frequently used the following economic indicators in freeport performance evaluation including development area of freeports, information technology, tax policy, the efficiency of customs clearance, and logistics services. The results of this study show that these indicators are all crucial in freeport sustainability evaluation and are among the top 10 KPIs. Specifically, information technology and the efficiency of customs clearance are the most important KPIs. Huang et al. (2020) also concluded that technology application is the most significant technical concern for policymakers in free trade port zones, and the quality of overall services can be improved by allocating more funds to develop advanced, automated, and efficient systems.

It is noteworthy that this study reveals varying perceptions among stakeholders regarding the three dimensions of sustainability in freeport evaluation. Researchers and public residents have higher preference for the environmental dimension compared to policymakers, practitioners, and service users. Some suggestions are proposed to bridge the gap. Firstly, stakeholders should improve communication and build partnerships. Secondly, policymakers should offer incentives and information to encourage service users to make environmental choices.

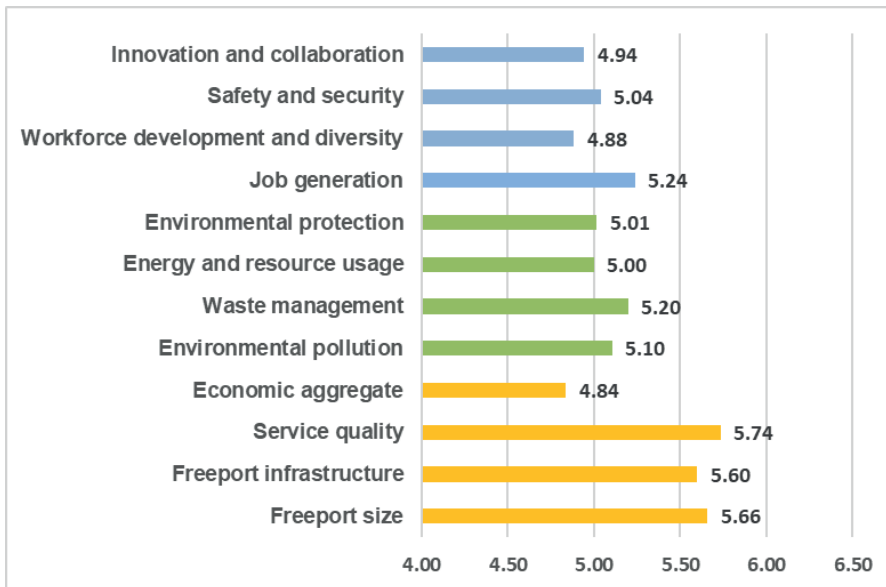


Figure 1. Importance scores of level-2 KPIs

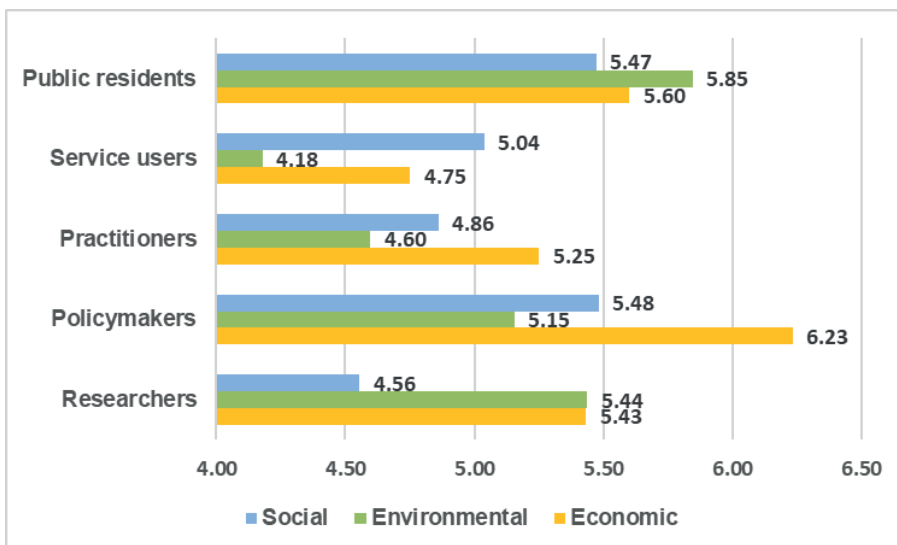


Figure 2. Importance scores of level-1 KPIs from multiple stakeholder perceptions

5. Conclusion

This study contributes to sustainability studies in the freeport sector by the followings. 1) It addresses the significant need for a synthetic index for sustainability evaluation, balancing economic, environmental, and social dimensions. 2) It identifies KPIs for freeport sustainability and analyses their importance, revealing service quality, freeport size, and freeport infrastructure as the most significant issues. 3) It compares multiple stakeholder preferences, finding that policymakers and practitioners exhibit a similar emphasis on the economic aspect, while researchers and public residents demonstrate a preference for the environmental aspect.

Future research should further refine the identified KPIs and explore more significant ones and test the robustness of the developed index system by real applications.

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NAVIGATING TOWARDS SUSTAINABILITY: ECONOMIC IMPACTS OF THE EEXI AND CII REGULATIONS ON MALAYSIA'S SHIPPING INDUSTRY

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Introduction

The International Maritime Organization (IMO) developed a preliminary greenhouse gas (GHG) policy in April 2018 to address the increasing concern about the environmental impact of global shipping. The IMO policy sets targets for reducing absolute GHG emissions and carbon intensity from international shipping. The objective is to cut absolute GHG emissions by at least 50% below 2008 levels by 2050 and reduce the carbon dioxide (CO₂) intensity of international shipping by at least 40% from 2008 levels by 2030.

The IMO's Fourth Greenhouse Gas Study in 2018 reported that international shipping's carbon intensity had already decreased by 22% compared to 2008, due in part to the widespread adoption of slow steaming in the industry. However, an additional 18% reduction in carbon intensity is still needed to meet the IMO's minimum carbon intensity target for 2030. The IMO is currently developing regulations to help achieve these objectives.

The IMO has tightened the Energy Efficiency Design Index (EEDI) carbon intensity rules for five new ship types, beginning in 2022. The organization is also developing measures to address emissions from the current fleet, which are expected to be finalized at the 75th meeting of its Marine Environmental Protection Committee (MEPC 75).

There are two types of short-term actions that have been suggested to reduce carbon emissions in the shipping industry: operational and technical techniques. Operational techniques include a carbon intensity rating system and an operational goal-based standard that directly limit the amount of CO₂ produced per unit of transportation effort. The most recent "hybrid" proposal suggests that ships will have to use both strategies in 2023 to assist the IMO in reaching its minimum 2030 carbon intensity objective.

The proposed technical measure is Energy Efficiency Existing Ship Index (EEXI), which is supported by several countries and organizations. The EEXI applies technical efficiency criteria to the existing fleet by restricting CO₂ emissions per unit of transport supply. Shipowners can comply with the EEXI through various methods, such as upgrading to energy-efficient systems, limiting the power of primary engines, or retiring ships early. The Engine Power Limitation (EPL) is seen as the simplest method for older ships to comply with EEXI regulations. The EPL limits a spacecraft's maximum power and speed by restricting the amount of gasoline that enters an engine. This would take the shape of a mechanical stop screw sealed by a wire that restricts the amount of gasoline that may enter an engine for mechanically operated engines.

On the other hand, Carbon Intensity Indicator (CII) is another parameter introduced by the IMO under the amendments to MARPOL Annex VI. CII measures a ship's carbon intensity, which is the amount of CO₂ emissions produced per transport work (e.g., per ton of cargo transported over a certain distance). CII is expressed in grams of CO₂ per tonne-mile. The goal of CII is to encourage ships to reduce their carbon intensity and improve their overall environmental performance.

Both EEXI and CII are part of the IMO's broader strategy to address climate change and reduce GHG emissions from the shipping industry. These measures aim to promote energy efficiency and encourage the adoption of cleaner technologies and practices in the maritime sector. By implementing EEXI and monitoring CII, the IMO seeks to drive improvements in the environmental performance of existing ships and mitigate the industry's impact on global emissions.

To assess the economic impacts of MARPOL Annex VI Requirements (EEXI - CII) on Malaysian-flagged ships, a study was conducted on several key aspects, including geographic remoteness and connectivity to main markets, transport dependency, transport costs, cost-effectiveness, initiative for emission reduction, socio-economic progress and development,

and safety navigational and environmental impact. The study was conducted in collaboration with the Malaysia Shipowners' Association (MASA), the Marine Department of Malaysia, the Ministry of Transport, and Universiti Malaysia Terengganu. It involved 48% of shipowner companies participating in a workshop, with 32% of them submitting the required data. The study was limited to Malaysian-flagged ships for domestic voyages, and the results showed that 60% of the studied vessels were rated in either D or E for CII.

This study aims to evaluate the preparedness of the Malaysian shipping industry in undertaking measures to minimize its environmental footprint by tackling GHG emissions and carbon intensity. The International Maritime Organization (IMO) has established emission reduction targets, and efforts are underway to develop regulations and strategies to meet these targets. Therefore, it is part of the stakeholders' responsibility to ensure that the shipping industry will continue to be both sustainable and environmentally conscious while ensuring its economic viability.

Geographic Remoteness and Connectivity to Main Markets

Remoteness refers to the state of being physically isolated, particularly from major population centers, leading to higher transportation and insurance costs. It hampers the visibility of local products in global markets, increases service fees, and limits participation in the global market. Additionally, remoteness can impact resource supply costs and incur additional expenses for infrastructure projects.

The United Nations Conference on Trade and Development (UNCTAD) developed the Liner Shipping Connectivity Index (LSCI) to measure remoteness in the maritime industry. LSCI considers factors such as scheduled ship calls, deployed capacity, shipping companies and liner services, vessel size, and the number of connected ports. The index is normalized to China with a score of 100 in Q1 2006. The Port Liner Shipping Connectivity Index (PLSCI) is used to assess port performance, while the World Bank Group's Logistic Performance Index (LPI) evaluates connectivity at the national level.

The impact assessment of the CII rating given to 57 fleets (domestic and international fleets) is based on the data collected during a 2-day workshop held in Putrajaya (Table 1).

CII Rating	Domestic Tanker (%)	Domestic Container Ship (%)	International Gas Carrier (%)	International Tanker (%)	International Bulk Carrier (%)	International General Cargo (%)	International Container Ship (%)
A	4	8	6.25	21.9	6.25	12.5	3.1
B	8	12	-	9.4	3.1	3.1	-
C	8	-	-	9.4	-	-	3.1
D	8	-	-	9.4	-	-	-
E	52	-	-	9.4	-	-	3.1

Table 1: CII Score for 57 Fleets

As shown in Table 1, domestic and small-sized ships travelling short-sea shipping routes have been observed to be more severely affected than bigger ships travelling longer distances. In short-sea transportation, the impact of slow steaming and reduced cruising speed is particularly visible. International ships, which are also required to travel at a slower speed, will have the ability to reduce transit time, increasing shipping disconnection and decreasing service frequency. Shipping routes and trading patterns can also be influenced by CII ratings. Routes that experience regular bad weather may become less appealing due to the impact on emissions. As a result, businesses will need to pay more attention to how they design the trip of their vessels.

Transport Dependency

The maritime industry plays a crucial role in global trade, accounting for 90% of transportation by sea. Technological advancements have increased connectivity and demand for goods and services. However, this growth has also led to significant environmental impacts, particularly carbon emissions from vessels. In Malaysia, industry players are committed

to promoting a green environment, aligning with the government's efforts to achieve carbon neutrality by 2050. The Malaysian government recognizes the importance of sustainability and is embracing concepts such as green energy, energy conservation, environmental protection, and sustainable development.

It is important to note that global CO₂ emissions per transport work in international shipping improved by 21% to 29% between 2008 and 2018, according to the 4th IMO GHG study. However, overall global maritime GHG emissions increased during the same period. Denmark, along with Germany and France, proposed a "mandatory operational goal-based short-term measure" to meet the 2030 GHG emission reduction target through operational means.

Maritime dependency, which refers to a country's ability to participate in maritime trade, is closely related to GDP, maritime trade, shipping activities, and local development. Compliance with energy efficiency (EEXI) and carbon intensity (CII) regulations is critical for shipowners as it enhances their image, prolongs vessel lifespan, and reduces environmental impacts. The interconnectedness and interdependency of countries worldwide emphasize the significance of maritime dependency in achieving sustainability goals.

Transport Costs

Transport costs play a crucial role in determining a country's capacity to participate in the global economy by facilitating international trade. The cost of shipping commodities by water makes up a significant portion of overall trade costs, including expenses for contract enforcement, information, policy barriers, currency rate changes, local distributions, legal and regulatory expenditures, and anything that widens the gap between exporting nation's production price and import nation's consumer price.

Assessing the relative size of transportation costs can be done in three ways:

- a) Ad Valorem transport costs, which compare transportation expenses to the worth of a good
- b) Comparing transportation expenses to other well-known trade barriers
- c) Looking at how much transportation expenses affect relative product pricing

It is important to note that transportation costs may be an even greater trade barrier than tariffs. The cost of goods is the cost that is incorporated in the final price of the goods that can be found in the importing country. A set of all current trade costs between the countries of origin and destination are included in the destination price of a good, sometimes known as the "Cost, Insurance and Freight" (CIF) price. These expenses are multiplied by the FOB (Free on Board) or factory price of the traded good.

Vessel running costs make up a significant portion of transport costs and include operating costs, maintenance costs, voyage costs, cargo-handling costs, and capital costs. The type of shipping contracts used, the shipping distance, and the type of goods transported also affect transport costs. Overall, it is important to consider and manage transport costs to ensure efficient and effective international trade.

Cost-Effectiveness

As a matter of fact, ships with 5000 GT or more are required to develop a Ship Energy Efficiency Management Plan (SEEMP) that includes the required CII values over the next three years, the implementation plan for reaching the required CII, CII calculation methodology, and measures for self-evaluation and improvement. This plan should be confirmed by the administration or Recognized Organization (RO). The CII requirement is dropped by 2% every year beginning in 2023. Corrective measures are not applied to ships with a C or above rating. However, ships with a D grade for three consecutive years or an E rating are subject to SEEMP remedial measures.

The results for the attained and required EEXI values for a sample of 24 ships are shown below:

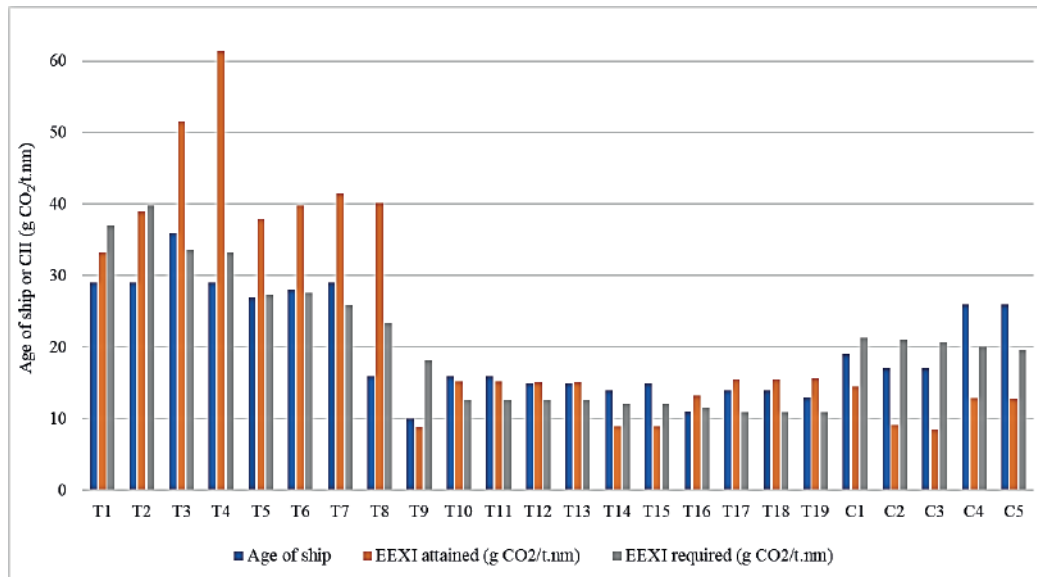


Figure 1: EEXI attained, EEXI required and age of ship for phase 2's (1 Jan 2020 to 31 Dec 2024) for 24 sample ships.

From the findings, it can be noted that only about 26% of the sample ships (tanker ships T1, T2, T9, T14, and T15) and all container ships (C1-C5) met the EEXI requirement. The other non-compliant domestic sample ships required an EEXI reduction from 12% to 46%. The age of the ship is an important element in determining the necessary EEXI values, but it does not necessarily lead to an equally good attainable EEXI.

On a separate note, the following Figures (Figure 2 and 3) show the positioning of the sample ships in relation to the attained and required CII values. One of the sample ships, T15, with an age of 15 years, can achieve label C until 2030 (year of label D for three consecutive years) compared to the other same-age tanker ships (T12 and T13) with a marginally different deadweight tonnage (DWT) and gross tonnage (GT). This is possibly due to the ship practicing just-in-time arrival, which leads to very short periods of time spent at anchor as perceived by the ship. By decreasing the amount of time spent in port and permitting even slower travel speeds, there is the possibility of realizing a greater reduction potential. Consequently, it is the responsibility of fleet owners and operators to examine the operational characteristics of their fleets to assess the appropriate and viable levels of Shaft/Engine Power Limitation (SHaPoLi) and Energy Efficiency Technologies (EETs).

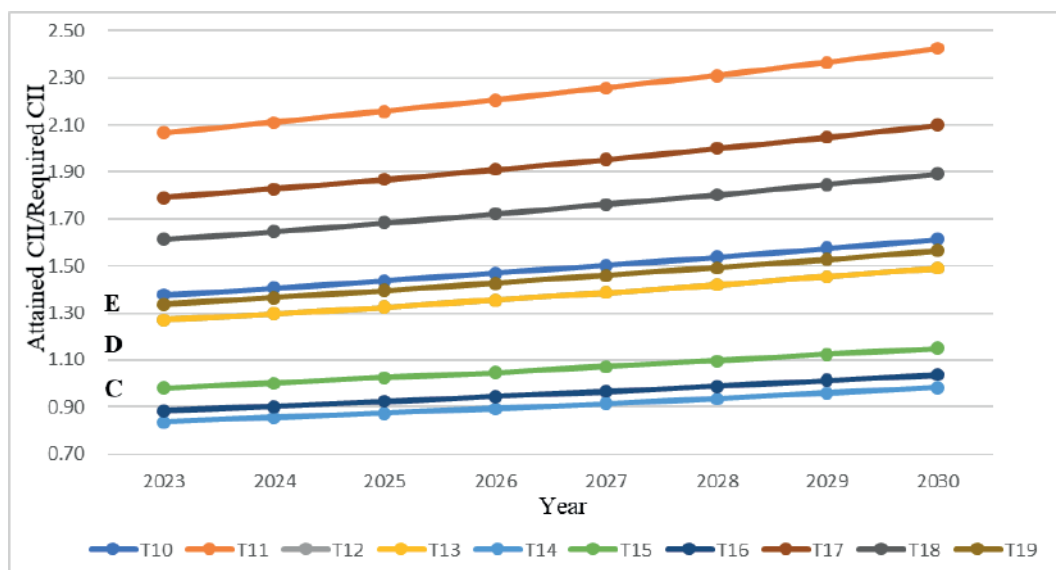


Figure 2: CII Rating for 10 sample tanker ships

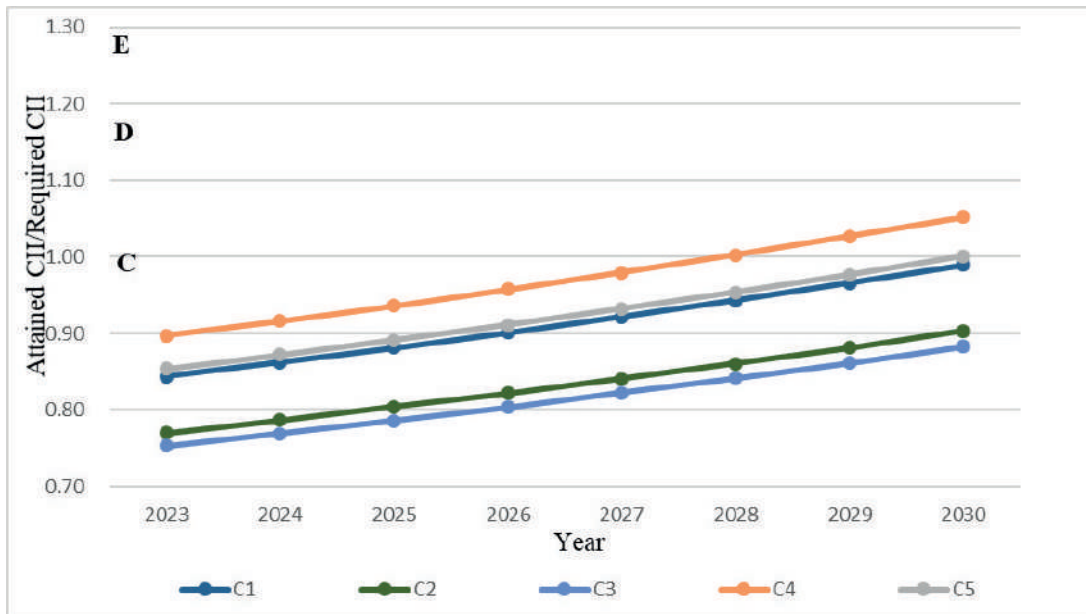


Figure 3: CII Rating for 5 sample container ships depending on CII value for 2023 to 2030

With regard to the cost of installing EETs, it is noted that 70% of the sampling tanker ships cannot comply even if they install SHaPoLi due to long payback periods. In addition, return on investment is based on future projected charter hire rates as opposed to ship operating expenses, which may be more consistent if there are no major impacts on the new EEXI requirement going forward. It is suggested that achieving a reduction in carbon emissions may result in ship service speeds being compromised, potentially compromising the safety of the ship during the passage. Additionally, the new technologies required may not be economically feasible, resulting in compliance challenges.

Initiative for Emission Reduction

In order to enhance operational efficiency and reduce CO₂ emissions through fuel consumption reduction, vessel operators should consider the following based on the different ways to reduce CO₂ emissions, which are either:

- Optimizing speed
- Installing engine power limitation (EPL), or shaft power limitation (SPL)
- Introducing new technologies with new types of fuels

For the first scenario, optimizing speed, the strengths identified are that the number of seafarers will not be affected, and shipowners will receive an EEXI compliance certificate. The weakness is that seafarers may face issues with maintenance strategies due to changes in running parameters, and safety may be compromised if the ship's speed is too slow. Opportunities include reduced workload for seafarers in terms of cargo operation, and shipowners may reduce fuel cost expenses. The threat identified is that seafarers may be at high risk sailing with ships that are not at a safe speed, and shipowners may have a high risk on the safety of their assets.

For the second scenario, installing EPL or SPL, the strengths identified are that seafarers will gain new knowledge on new technologies in the marine industry, and shipowners will optimize fuel consumption and comply with EEXI. The weakness is that seafarers will need additional workload in terms of monitoring and maintenance, and extra equipment will lead to extra maintenance (record keeping). Shipowners will have to incur new costs for new equipment installation and establish new procedures for maintenance to comply with the requirements. Opportunities include the development of new skills for seafarers and the possible opening of new business opportunities for shipowners. The threat identified is that with new monitoring devices or equipment installations, there may be an increase in the possibility of human error without proper training, which could lead to incidents.

For the third scenario, introducing new technologies with new types of fuels, the strengths identified are that seafarers

will gain new knowledge on new technologies in the marine industry, and shipowners will comply with EEXI and have more business opportunities. The weakness is that seafarers will need new working skills or certifications as new propulsion systems are introduced, and shipowners will incur new costs for building new vessels or installing new engines. Opportunities include the development of new skills and certifications for seafarers. The threat identified is that shipowners will have to incur new costs for new building of vessels or new engines, and may have to establish new procedures for management (PMS/Training/Safety).

Socioeconomic Progress and Development

The adoption of market-based policies is crucial in achieving the International Maritime Organization's (IMO) 2030 and 2050 targets for reducing greenhouse gas (GHG) emissions in the international shipping industry. This approach recognizes that technical and operational solutions alone are insufficient, emphasizing the need to internalize the external costs of emissions through market mechanisms, such as adopting market-based policies to internalize the external costs of emissions.

Various technical solutions, including the Energy Economy Design Index (EEDI), have been developed, but the shipping industry has been slow to adopt new technologies due to high costs and uncertain investment returns. Operational solutions such as speed optimization and hull cleaning have been effective in reducing emissions, but there are limitations to their effectiveness. The Ship Energy Efficiency Management Plan (SEEMP) is a voluntary recommendation aiming to improve energy management but lacks a mandatory requirement.

The argument presented is that the adoption of market-based policies, such as the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII), can have a significant impact on reducing emissions. Market forces have historically driven innovation in the shipping industry, with changes in fuel prices prompting the exploration of alternative energy sources and operational techniques. Ultimately, embracing market-based policies is necessary to achieve the IMO's emission reduction targets and keep global warming well below 2°C.

Safety Navigation and Environmental Protection

There are various ways to achieve significant reductions in a ship's CO₂ emissions, such as by slow steaming, installing and implementing new energy efficiency technologies, using alternative fuels, or making operational changes such as rerouting or limiting cargo intake.

The EEXI and CII measures are not expected to cause any direct challenges to the safety of navigation once the ship has received the certificate of compliance. However, the implementation of advanced technology or system, speed, and route adjustment, and stability adjustment may impact the navigational officer's ability to see while performing their duties, alter the vessel's maneuvering characteristics, and affect intact stability.

A SWOT analysis was conducted from the seafarer and ship owner perspectives. The strengths identified included the opportunity for seafarers to learn new technology, creating more awareness about the importance of achieving zero emissions, optimizing monitoring systems, and increasing the company's reputation. The weaknesses identified included obstructions to navigation due to the adoption of new technology and potential added costs for compliance. Opportunities identified included the development of new technology and the increased demand for sustainable shipping. The threats identified included the potential for competition from more environmentally friendly ships and the potential for decreased profitability due to added compliance costs.

Prospective

It is notable that shipowners could implement numerous measures to reduce carbon intensity (CII) and meet the target set by MARPOL Annex VI. Some of the measures include speed reduction, optimized routing, fleet management, retrofits to reduce resistance, engine modifications, installation of energy-saving devices, transitioning to electric or hybrid propulsion, and adopting alternative fuels. However, implementing these measures may have adverse impacts on industry players, such as potential degradation in cargo quality, increased in-transit inventory costs, a shift in cargo transportation to faster modes, higher freight rates, increased lifecycle GHG emissions, and challenges in financing retrofitting or investing in new ships. Therefore, a holistic approach and collaboration among industry players, regulators, and other stakeholders are extremely crucial to address these challenges and creating a more sustainable shipping industry while minimizing unfavorable impacts.

Conclusion

By 2050, the transformation of the shipping sector into a fully decarbonized powerhouse will revolutionize the entire industry, surpassing the boundaries of our current system. This remarkable achievement, however, hinges on the worldwide decarbonization of the energy landscape. The significance of implementing substantial changes in domestic energy systems cannot be overstated, as they hold the key to mitigating the shipping sector's CO2 emissions.

Nevertheless, the urgency to act cannot be underestimated. Without the prompt implementation of well-directed policies to address demand, technology, and operations, the task of budget allocation for future years could evolve into an insurmountable challenge, bordering on the impossible. The present circumstances demand immediate and decisive measures, as the fate of achieving a decarbonized shipping sector and the precarious future of sustainability are on the line.

CHARGING URBAN FLEET ELECTRIC VEHICLES VIA LIGHT RAIL SYSTEM POWER GRIDS

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Introduction

As the proportion of society living in urban areas increases and the impacts of climate change become more significant, it is more important than ever that cities become sustainable, healthy places for people and for the planet. The strict air quality standards required by urban Low Emission Zones (LEZ) take a step towards this by reducing the levels of pollutants in urban areas, through incentivising road vehicle users to switch to low- or zero-emissions vehicles, or simply to a different means of transport altogether. However, in order to make the switch, adequate access to charging infrastructure is required. Logistics vehicles are often subject to more stringent LEZ fines than private cars, while fleet managers face the added challenge of trying to charge large numbers of vehicles. This paper focuses on how linking up electric vehicle (EV) charging for fleet vehicles with urban light rail networks could facilitate an increase in the uptake of low emission vehicles via improved charging access, and simultaneously reduce energy wastage in light rail systems.

Background and literature review

Edinburgh, UK, has a LEZ that is due to come into force in summer 2024 (Lamb n.d.). As is common across Europe, Edinburgh's regulations primarily target large diesel vehicles, such as buses, freight vehicles, and vans (Ellison, Greaves, and Hensher 2013). A 2023 survey of vehicles entering and leaving Edinburgh's zone area found that compliance rates have risen significantly since the zone was first proposed in 2016 (Gordon n.d.). While 97% of buses were found to be LEZ compliant, approximately 35% of light commercial vehicles and 14% of HGVs entering Edinburgh city centre were found to exceed the maximum emissions restrictions.

One means by which businesses and public services can ensure their vehicles are LEZ-compliant is by phasing in electric alternatives. LEZs are driving a worldwide expansion in the market share of electric light commercial vehicles, the majority of which are owned by businesses (International Energy Authority 2022). Uptake of electric buses and trucks is also increasing globally. However, access to appropriate charging infrastructure is a major constraint on the practical usability of heavy-duty EVs. Both slow charging facilities for overnight use and rapid charging facilities for mid-shift top-ups are needed to make commercial fleet EVs a widely feasible option. Fast charging infrastructure is more valuable here, as it increases the throughput, and therefore the utility, of each charging point (International Energy Authority 2023). However, most forms of charging infrastructure increase the load placed on local and regional electrical supply networks. This can be avoided by using charging solutions not connected to the main supply grid, through technologies such as microgrids.

One option for increasing urban EV charging capacity without increasing grid demand is to link up chargers with existing local grid networks, such as light rail systems. This can come at a lower cost than installing new chargers on the main grid network (Fernández-Rodríguez et al. 2019). Light rail system supply grids often have spare capacity, particularly outside of peak times (Amsterdam and Warmerdam 2023). Such a solution could also improve the energy efficiency of local electrified transportation systems. A large proportion of the power produced through the regenerative braking systems deployed every time a tram or metro train slows down is wasted, due to the design of the DC (direct current) supply network. The Madrid metro system has EV charging points that allow members of the public to charge their vehicles with this wasted energy (S.A 2017; Fernández-Rodríguez et al. 2019). Alternatively, the use of vehicle-to-grid technology would allow EVs to act as temporary energy storage, capturing the regenerated energy at the point of wastage and releasing it back into the light rail system as required. Araúz and Martinez estimate that such a system could cut light rail system energy consumption by 20-30% (Araúz and Martinez 2023).

In order to determine how EV charging could best be linked with light rail supply grids to benefit both transport types, it is necessary to determine when, where and how much energy is wasted by the light rail system. Such information is not typically recorded by system operators. Estimates of energy use in light rail systems rarely account for the motion or braking patterns of the actual trams or metro trains moving on the network. This information is particularly important for surface-level tram systems, such as those in Edinburgh, as the geography of the system impacts how much energy is released during braking events. As Edinburgh's light rail system has sections of track shared with the public road, levels of vehicle and

pedestrian traffic impact how often trams need to brake, and thus affect energy regeneration. Zhang et al. (2021) used GPS tracking of tram journeys to determine the actual number and nature of braking incidences incurred by trams in Sheffield, UK to estimate the energy regenerated.

Research approach

This paper investigates the potential for linking up Edinburgh's light rail system with EV charging opportunities, in order to increase EV proliferation for fleet vehicles operating within and outside of the LEZ, and improve the energy efficiency of the tram network. The steps taken in this investigation are:

- Examine Edinburgh tram network and identify potential fleet EV users,
- Use GPS data to model where regenerative braking occurs, and the resultant electrical current / energy,
- Estimate how much of the regenerated energy would be available at the selected fleet charging locations, and
- Consider the available energy in terms of numbers and ratings of EV chargers.

Edinburgh tram network

Edinburgh's light rail network consists of one 18.5km line with 23 passenger stops. It runs between Edinburgh airport (west of the city) and Newhaven on the north-east coast, with stops serving the city centre. The network is supplied by eight unidirectional substations. These substations cannot transfer current to other areas of the grid or return it to the supplier, so the network is effectively split into nine discrete energy supply sections. It is therefore necessary for EV charging capacity to be installed in all of these supply sections, in order to minimise energy wastage. A range of different potential fleet EV users have been identified to serve as indicative users for this paper, in order to consider a variety of vehicle types and charging needs. Figure 1 shows the supply sections along Edinburgh's light rail network and indicates the EV charging sites selected.

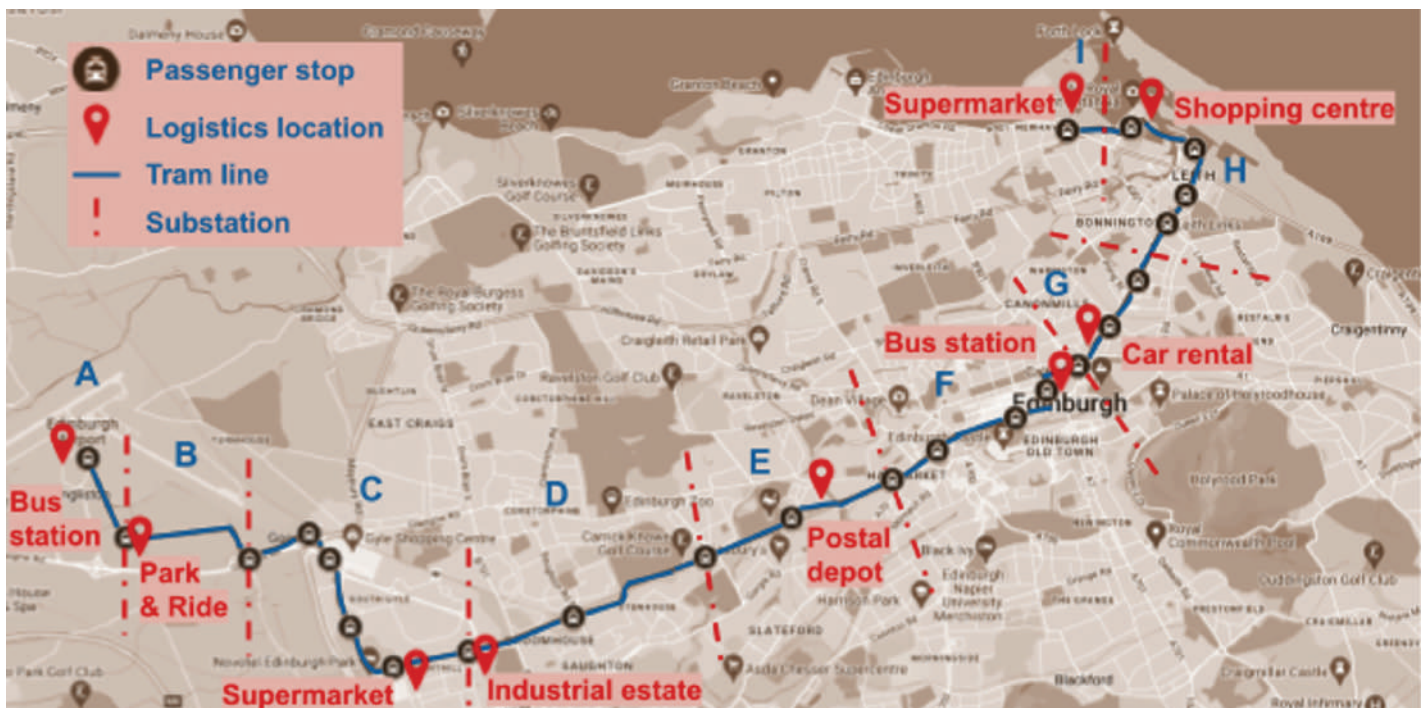


Figure 1: Map of Edinburgh's light rail system indicating energy supply sections A-I, and potential locations for fleet electric vehicle charging in each section.

GPS modelling of regenerative braking

In order to estimate the times, locations and quantities of energy produced by regenerative braking on Edinburgh's light rail network, it is first necessary to determine the times, locations and intensities of braking that take place. GPS recordings of journeys east- and westbound along the entire tram route were captured by a passenger on a tram using a handheld GPS device. These recordings captured the location of the tram at a frequency of 1Hz, allowing the speed and acceleration of the tram to be determined for any point along the route.

Information about the tram's speed and acceleration can be used to determine the force F required to move the tram forward or slow it down. The forces acting on a tram in both of these situations are shown in figure 2. The tram motion force F is given as:

$$F = ma - R$$

Where m is the mass of the tram, a is the acceleration of the tram and R is the resistive force experienced as a result of vehicle design and track geography. A value of $m=56.96$ T was used for this model (Bilfinger Berger, Siemens, and CAF 2008).

Resistive force R can be expressed as

$$R = Q + C + G$$

Where Q is the basic resistance of the tram as a result of vehicle design, C is the resistance experienced due to the additional friction encountered when trams round corners, and G represents the additional force required to climb slopes.

Basic resistance Q can be modelled as:

$$Q = \alpha + \beta v + \gamma v^2$$

(Chymera et al. 2010)

Where v is the speed of travel, and α , β and γ are the bearing resistance, rolling resistance and air resistance coefficients, respectively, of the tram design. The design coefficient values were obtained from tram specifications (Balfour Beatty Power Construction Limited 1991).

Curvature resistance C can be modelled as:

$$C = mg \frac{A}{r}$$

(Yi 2017)

Where g is acceleration due to gravity, r is the radius of curvature of the bend (assigned based on tram location from GPS data), and A is an experimentally determined constant relating to vehicle speed. For all light rail applications, $A=600$.

Gradient resistance G can be approximated to:

$$G = mg \sin \theta$$

(Chymera et al. 2010)

Where θ is the angle of the slope climbed, which can be determined by the change in elevation of the tram. The elevation of the tram can be obtained from its location at any point.

The force required to move the tram forwards or slow it down is directly proportional to the electrical current, I , drawn by the motor or produced by regenerative braking. This relationship can be characterised as:

$$F = kI$$

(Zhang 2021)

Where I is the current required or released, and k is a constant of proportionality determined by the efficiency of the motor in converting between force and current. As tram motors are designed to prioritise efficient forward motion, Zhang estimates that $k=14$ during acceleration and $k=10$ under braking conditions (Zhang 2021).

As well as requiring current to move forwards, trams have an additional power draw to supply onboard services such as heating, lighting and wifi. When regenerative braking occurs, the energy required for these auxiliary functions is automatically drawn from the regenerated supply rather than the tram grid. The current required for this was calculated using manufacturer ratings for the onboard services (Bilfinger Berger, Siemens, and CAF 2008) and subtracted from the total current produced by a tram.

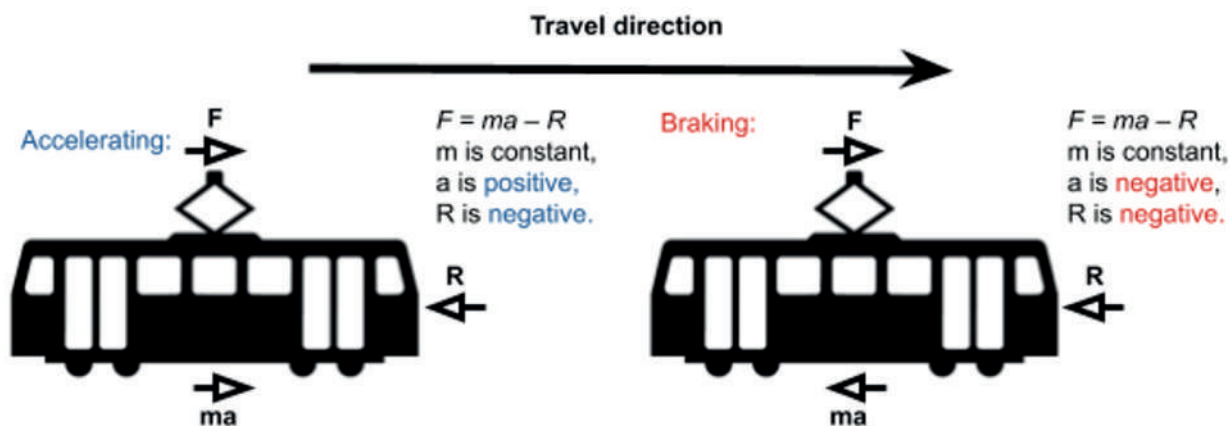


Figure 2: Forces acting on a tram during acceleration and braking.

Current availability estimation

The total current available to each suggested EV charging hub (shown on figure 1) depends on the distance from the tram to the hub, and how many trams are in the supply section at one time. Trams only produce energy when braking, so the energy available for EV charging is not necessarily constant or consistent. In some cases, energy is shared directly between trams. Such energy sharing only occurs when one tram is braking while another one is accelerating within the same supply section. The proportion of energy shared depends on the intensity of braking and acceleration occurring and the distance between both trams and the supplying substations. It is therefore difficult to estimate with any accuracy at any given time, although averaged over a day, the energy share is predictable.

In order to estimate the energy that could be made available at each EV charging hub, the maximum and minimum non-zero values of energy produced for east- and westbound tram journeys through each supply section was obtained from the results of the GPS model. Any current spikes more than 50% larger than the rest of the results in the supply section were discarded. The maximum number of trams in each supply section was estimated based on the tram timetable (Edinburgh Trams 2023). These upper and lower bounds were combined to give upper and lower estimates for the energy available to each EV charging hub.

Application to EV charging

Since both the power supply network and the regenerative braking output of Edinburgh's tram system is DC, it is well-positioned to offer DC fast charging. DC EV charging is increasingly popular as it can charge vehicles in relatively short periods. The estimated number of chargers each supply section could support during full tram timetable operation is therefore based on the current supply requirements of 60kW and 160kW Ultracharge DC fast chargers (ROLEC EV and Sinexcel 2023). Two different charger size options were used to reflect the range of vehicle types and charging needs at each location.

Results

Figures 3 and 4 show the current that a single west- and eastbound tram journey could supply to the EV hub location in each energy supply section.

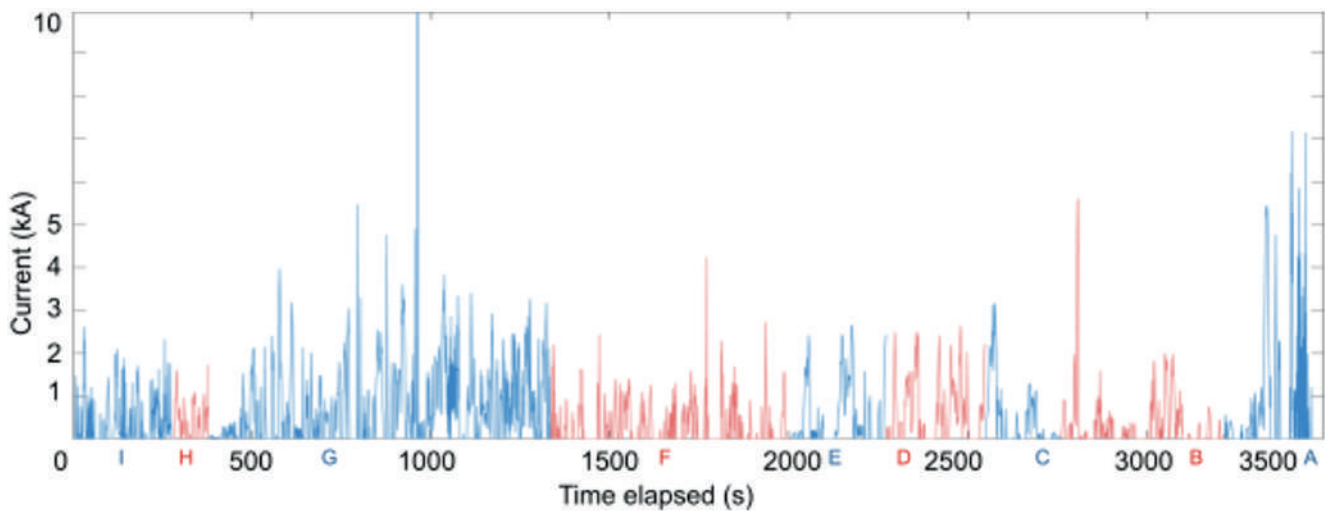


Figure 3: Current that could be made available to each EV charging hub by a single westbound tram journey. Supply sections are denoted by alternating colours.

Figure 5 shows the maximum number of trams in each supply section at any given instant, and combines that information with the results in figures 3 and 4 to estimate the maximum and minimum current that could be supplied to each location during normal operational hours. Figure 6 puts the information from figure 5 in terms of the number of 150A rapid DC charging points the minimum estimated current could support.

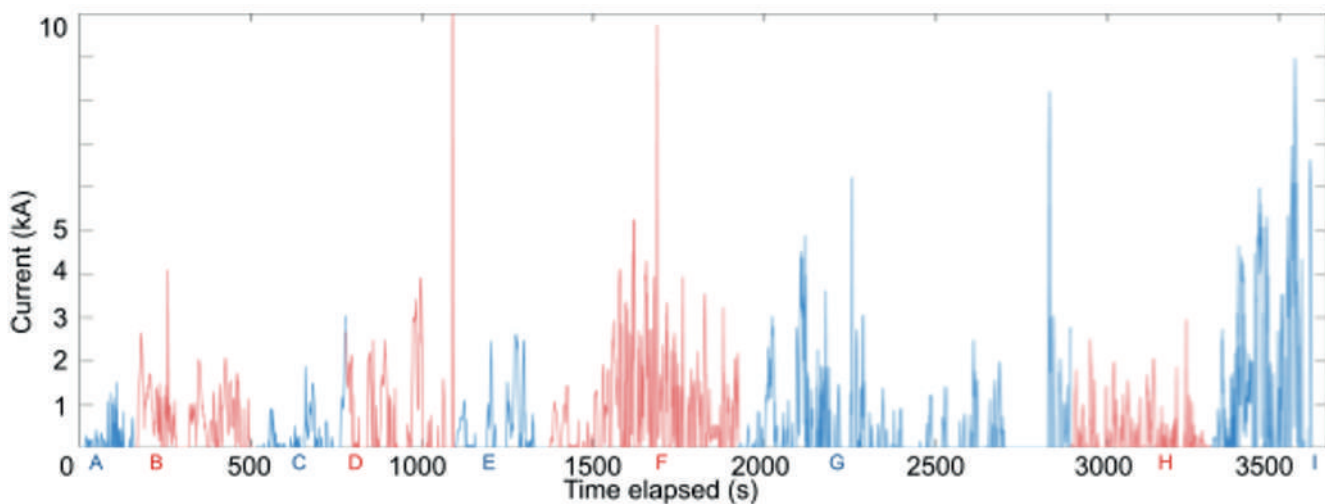


Figure 4: Current (kA) available to each EV charging hub by a single eastbound tram journey.

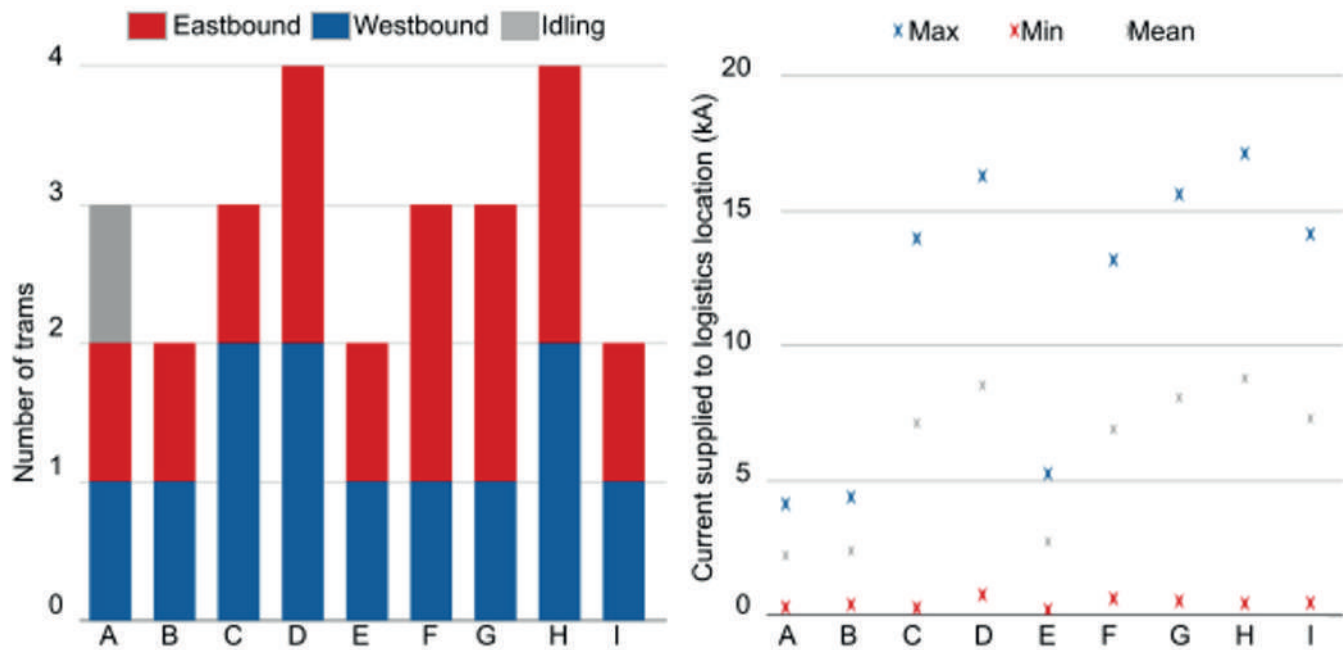


Figure 5: (a) Maximum number of trams in each energy supply section, according to the timetable. (b) Current (kA) available to each logistics location.

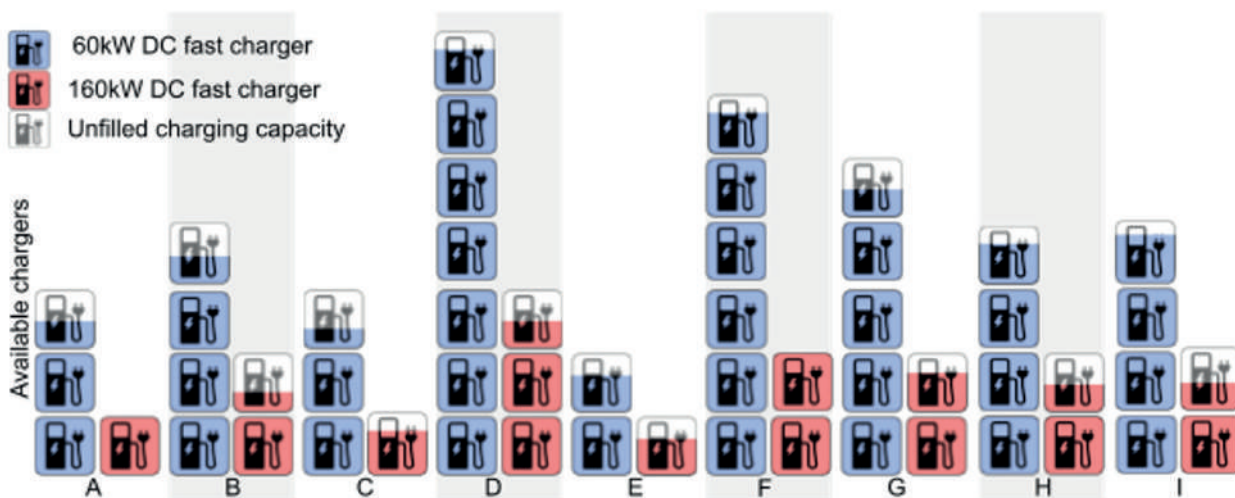


Figure 6: Two alternative solutions for the number of DC fast charging points that the minimum estimated current in each supply section could support.

Discussion

Figures 5 and 6 show that there is notable potential for DC fast charging using energy currently wasted by the light rail system in Edinburgh. Such a system would improve EV charging opportunities and reduce the significant amounts of energy wastage occurring in the light rail system. Supply sections D and F for example have greater charging potential, and may be able therefore to support faster DC chargers than investigated in this paper. This would be advantageous when considering logistics vehicles, as it would allow rapid top-up charging of heavy-duty vehicles such as buses and trucks during their hours of operation. With the option of sufficiently fast chargers being made available, such top-up charges could take place during loading/unloading time or driver breaks.

Figures 3 and 4 include some significant current spikes. More detailed modelling is needed to understand what causes these fluctuations, and what impact they might have on energy availability at potential charging locations. More detailed estimates of the impacts of trams deviating from the timetable (and therefore wider variation of how many trams are in each supply section at any given time), time of day and road traffic patterns, and tram mass are needed to improve the precision of energy availability estimates at each location. However, the minimum estimated chargers are likely to represent charging capacity that could be made available continuously, as when trams are not running the light rail grid infrastructure will still be capable of delivering this level of current to the charging hubs. Investigation of what kinds of vehicles would be available at different potential EV hubs close to the tram network is also needed, in order to determine what level of rapid DC charging would be most appropriate.

Conclusions

In summary, there is significant potential to use Edinburgh's light rail system energy supply grid to support rapid DC charging of EVs. Such a collaboration would reduce energy wastage in the light rail network and provide rapid charging opportunities for mid-shift recharging of EV logistics vehicles. This in turn would help to increase compliance with Edinburgh's LEZ and have a positive impact on urban air quality. Further research is needed to increase the precision of energy availability estimates and ensure that the charger types modelled are appropriate for the kinds of vehicles that make up local fleets.

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UNDERSTANDING THE RURAL DEMOGRAPHICS NEED FOR ELECTRIC VEHICLES

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Introduction

The transport sector is one of the largest contributing factors to UK emissions (DfT, 2021). In order to achieve the ‘net-zero’ targets set by the UK Government (BEIS, 2019), their latest “Ten Point Plan” details the ending of sales for new petrol and diesel vehicles by 2030 (Energy Saving Trust, 2021). Electric Vehicles (EVs) are low emission vehicles which provide a positive contribution to this goal (Hirst, 2020).

The transition from Internal Combustion Engines (ICE) to Electric Vehicles (EVs) is already underway, however there is a risk of rural areas falling behind. Rural communities have often been left behind during large-scale socio-techno transitions in the past, for example, Internet and Mobile Phone Connectivity (Williams et al., 2016). The UK Governments “Road to Zero” strategy outlines this transition but also expects the transition “to be industry and consumer led” (DfT, 2018). This approach gives rise for concern, as it will only work for locations where there is a strong business case (Cooper, 2018). It is also unlikely that market forces alone will lead to the installation of EV charging points in rural areas, where the customer base is significantly smaller than urban areas, and the cost of grid connections can be very high (House of Commons, 2018).

Vehicles are crucial for rural communities, where public transportation options are limited (Better Transport, 2018), and utilities and amenities are spread further apart leading to considerably more car usage (Newman et al., 2014). Considering, 9.7 million people live in rural areas (within England alone) (DEFRA, 2021), who one day will have to change their vehicles to conform with government legislation (currently the only viable option being EVs), it is imperative these areas are considered appropriately for such change.

This paper presents results from an online survey that has been targeted towards rural households to gather information on their vehicle usage, EVs ownership, and associated technologies such as charge points and electricity meters, together with their demographic. Results have been analysed to provide insight into the EV transition in rural areas and highlight the nuanced perspective of the EV transition in rural areas, ensuring that these stakeholders views are understood and integrated.

The remainder of this paper is organised as follows; firstly a review of relevant literature and how the papers scope fits in is presented. The ‘Research Approach’ section details the survey developed for this data collection exercise, including its core sections and distribution methodologies. This is followed by the ‘Results & Discussion’ section, and finally the ‘Conclusion’ section.

Literature Review

Although there is a general lack of consideration for the EV transition in rural areas from a political aspect, there have been some studies conducted which focus on it, albeit these are fewer than urban focused studies. Newman et al. (2014) argued that the pre-disposed premise that EVs are most appropriate for urban areas may not necessarily be true. They argue that a compelling case can be made for EVs in sub-urban and rural areas. This includes the typically longer commuter ranges witnessed in these areas (30-80 km round trips), which Newman et al. (2014) states are a better match to the discharge-recharge cycle of an EV battery. However, this would leave little capacity left in an EV driver to conduct additional travel without recharging and thus would delay the start time of any additional travel. Although, due to the longer distances witnessed during rural travel compared to in the urban environment, the operational cost advantage only becomes greater for running an EV over an ICE vehicle.

Additionally, rural households often have larger space available, including the prevalence of designated off-street private parking (e.g. driveway, garage, carport etc) (Newman et al. 2014). This allows for the possibility of home charge points to

be installed, reducing the dependence of the rural driver on public charge points which can often be the case in urban areas (e.g. terraced houses). Compounding the case for EVs in rural areas, due to the dispersed nature of amenities (e.g. shops and utilities), charging points at public locations become more useful and improve their business case (Newman et al. 2014).

Jones et al. (2020) also highlight not only the lack of focus on the challenges faced by the rural community regarding the EV transition but also notes the possible suitability of EVs in these settings. Jones et al. (2020) assessed the impact of rurally based businesses adopting EVs for their transportation and found them to be a suitable substitute for their existing transport, provided there is the required support (infrastructure enhancement and technical developments).

Hardman et al. (2018) conducted a large scale literature review of studies investigating infrastructure needs to support EV integration, which included a brief overview of multiple questionnaire surveys which have been deployed in the past. From the review conducted by Hardman et al. (2018), Dunckley and Tal (2016) found most US based EV drivers only charge at home, with some charging at home and work. Dunckley and Tal (2016) surveyed over 4,000 EV owners across 11 states to investigate the attitudes and perceptions of EV owners with regards to the roles of electricity companies and grid operators in this transition and the market itself. The only criteria for participation was ownership of an EV, with no published statistics on their location (i.e. if participants lived in a rural or urban environment). Although from the demographics they did collect, 98% reported living in detached houses (Dunckley and Tal 2016).

Graham-Rowe et al. (2012) highlights the need for infrastructure investment to convince consumers to adopt EVs. This came following a questionnaire conducted with 40 UK non-commercial drivers at the end of a 7-day period using an EV, the first UK EV trial focused on mainstream consumers. Participants belonged to Berkshire, Hampshire, and Surrey regions and included a location parameter in their selection which included rural, urban, or suburban. Of the 40 participants, 20 lived in a suburban environment, 13 in urban and 7 in rural locations (Graham-Rowe et al., 2012). As is the case for many individuals still today, the prioritisation of personal mobility outweighs environmental benefits (Graham-Rowe et al., 2012). This is also corroborated by Bailey and Axsen (2015) and Skippon and Garwood (2011) who also found that workplace charging was ranked as the second most likely influence for EV purchasing, after home charging.

Carley et al. (2013) also surveyed consumers intent on purchasing EVs, although this study was focused on consumers within large US cities. As detailed, there are many examples of conducted surveys which have aided the understanding of the EV transition. However, few examples of surveys focus on rural areas alone, attempting to capture any nuances these environments pose towards the transition. This paper attempts to fill this gap within the literature.

Research Approach

To engage these specific stakeholders, an online survey was developed using Google Forms. This survey consisted of 18 questions, across 5 core aspects related to the EV transition: (1) Demographic, (2) Your Cars and Travel, (3) Electric Vehicles, (4) Charging and (5) Electricity Tariffs.

The first core aspect, 'Demographic', recorded information pertaining to the area of the respondent, as well as the number of people and their respective ages living at the household. A keynote is the survey was developed to be completed from the perspective of a household, not one individual. Flyers were used to distribute the survey, via letterboxes of households within the specified area of interest (Peak District, UK). The total area within which the survey was distributed across can be seen in figure 1.

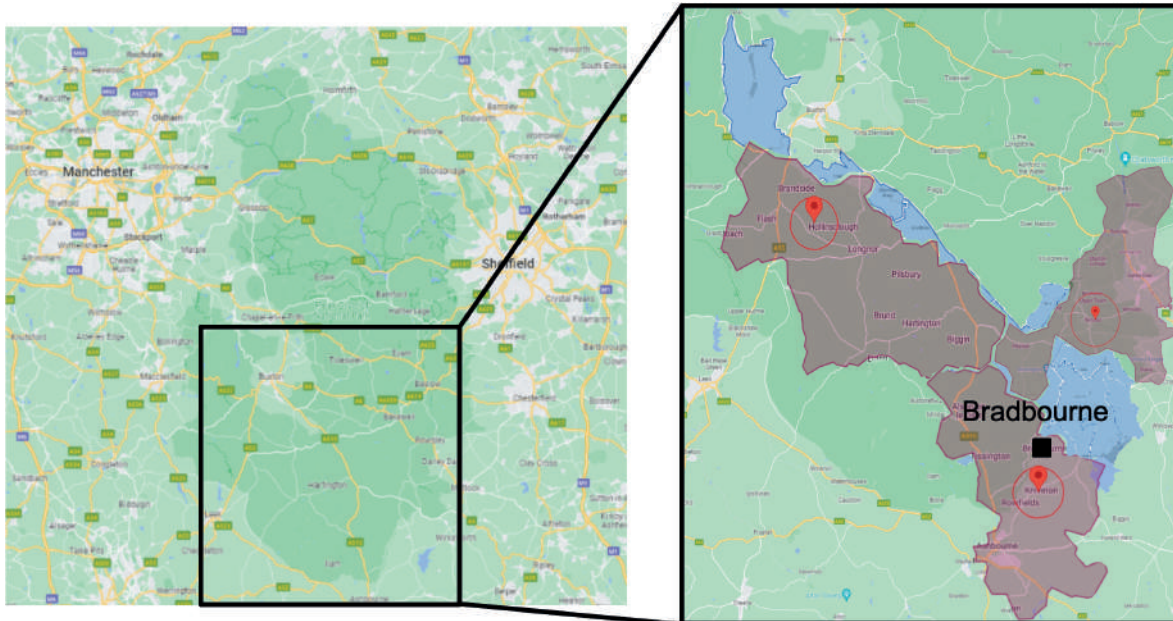


Figure 1: Map of distribution for survey flyers

Multiple survey distribution methods were employed over a 9 month period, utilising the Royal Mails Door-to-Door Campaign service, local parish councils, hand delivery and contacting local schools in the area.

The second core aspect, 'Your Cars and Travel', was incorporated to discern car availability and usage for each household. From a technical standpoint, this data is vital to understanding the requirements rural individuals have for their vehicles. Gaining that understanding then allows analysis into the feasibility of EVs, considering their compatibility with rural specific usage. Previous work conducted by the authors looked to simulate the impact of EVs in rural areas and a pre-requisite for this was the development of a travel demand model (TDM). This TDM simulated how each vehicle in a small village, Bradbourne (highlighted in figure 1), travelled over the course of a week. This survey, and in particular this core aspect, supports the validation of this model and its results. However, presentation of the models results, and their validation are outside the scope of this paper and will not be discussed further.

The 'Electric Vehicles' section was used to understand not just awareness of EVs and the transition within the rural community, but also ascertain the acceptance of this transition. Additionally, questions on local public transport were included. These were devised to capture opinions on the EV transition, and by extension, highlight any issues they foresee so that they may be addressed.

The following section, 'Charging', provided an opportunity to investigate charge point allocations and capabilities for rural households in terms of parking, anticipated number of chargers people would like and where they envisage charging their EVs. These questions were framed to be answered regardless of ownership of an EV and so invited participants to contemplate a future scenario.

The final section, 'Electricity Tariff' concluded the survey and was added to understand associated EV technologies such as EV specific electricity tariffs and electricity meters.

Results & Discussion

Over the course of 11 months, over 12,000 flyers were distributed to households within the highlighted area of figure 1. From which 192 responses were received, representing 192 households, that pertained to over 500 individuals and 376 vehicles. The survey results which will now be presented and discussed and will henceforth be referred to as 'Data Collection' in figures.

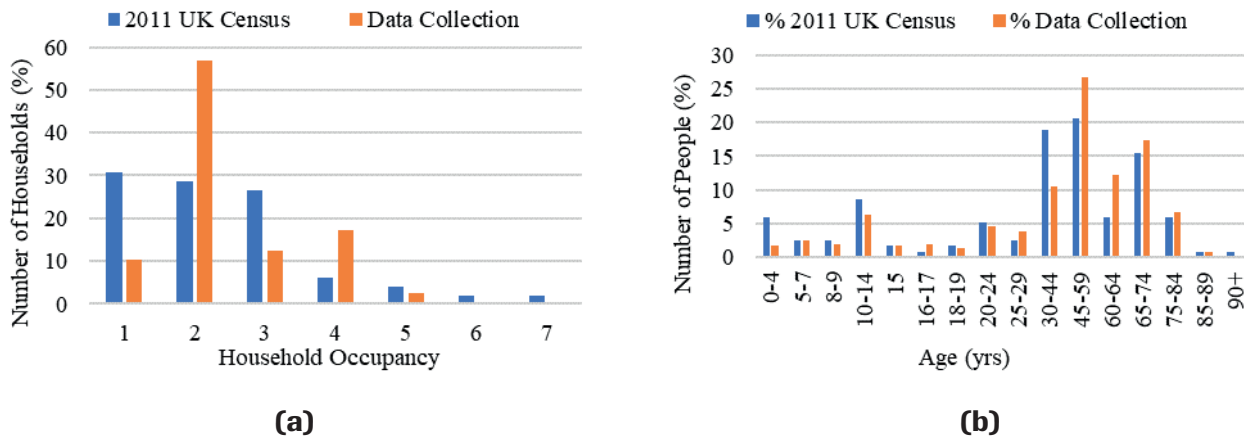


Figure 2: (a) Household Occupancy, (b) Age of Respondents

Figure 2 (a) presents the distribution of household occupancy for each response, whilst figure 2 (b) indicates the age profile of all 500 individuals (by percentage) captured across the 192 responses. Data from the 2011 UK Census, pertaining to Bradbourne specifically, has also been included (UK Data Service, 2011) for comparison in figures 2 (a) and 2 (b). As shown the data collected in is line with that collected by the 2011 UK Census, validating its usability for real-life deductions.

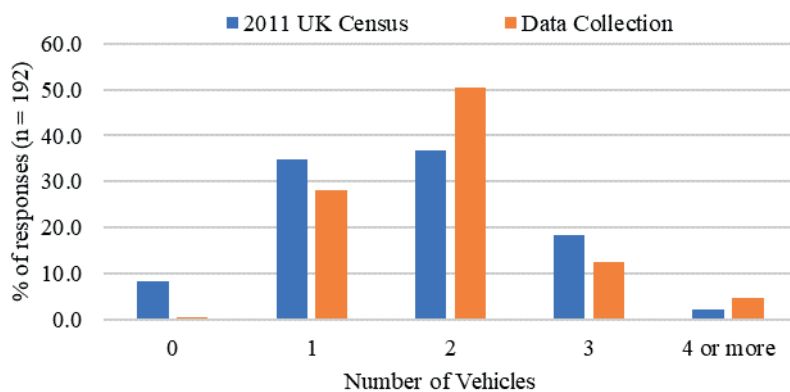


Figure 3: Number of Vehicles per Household

Across the 192 households that responded, 376 vehicles were owned, averaging out to 1.99 vehicles per household. The full distribution can be seen in figure 3. Of these 192 households, 33 had EVs already, corresponding to a total of 38 individual EVs. The average number of vehicles per household increased to 2.12 when solely considering these households with EVs. This is not surprising as EV households are much more likely to be multi-vehicle households. These results highlight the current perception that EVs are deemed a secondary vehicle, with the need for a primary vehicle to be reliable and thus petrol or diesel. Although households are adopting EVs, only 7 households (3.6% of total responding households) had an EV as their only vehicle.

With regards to vehicle usage, each household travelled an average of 214 miles per week. When considering only the 33 households with EVs, this increased to an average 280 miles per week. This is most likely due to the typical narrative of EV households being multi-vehicle households and so naturally, more vehicles results in more miles driven. From an individual vehicle perspective, each of the 376 vehicles averaged 110 miles per week.

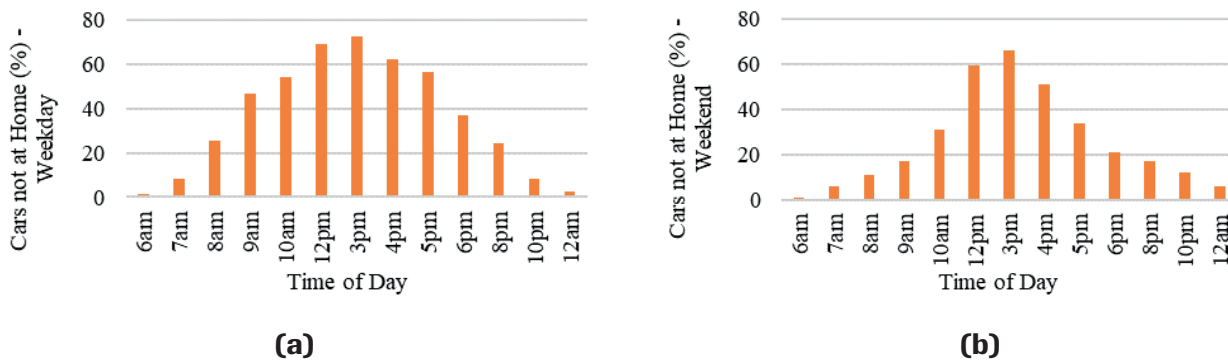


Figure 4: Cars not at Home, (a) Weekday (Mon-Fri), (b) Weekend (Sat-Sun)

A crucial part of assessing the feasibility of EVs in rural areas is understanding the impact they will have on local grid infrastructure. This impact will be largely determined by the charging profiles of each vehicle, and cumulatively, their aggregation together from the perspective of the grid. Therefore, this survey sought to understand when cars are available throughout the day for home recharging events. Figure 4 displays the results of this for both the average weekday and weekend. Both indicate the suitability for overnight charging, a behaviour currently being heavily anticipated and pushed by grid operators, via EV energy tariffs.

From the ‘Electric Vehicles’ section, over 91% of respondents indicated that they are aware of the EV transition, however this only translated into 19.3% of households anticipating their next vehicle to be an electric one. In contrast, 37% of respondents actually responded that it would be ‘Very Unlikely’ that their next car would be an EV. This indicates a reluctance towards EVs. Price, range anxiety and distrust of the technology all rank highly as barriers for EV adoption; however it is also prudent to note that the rural population is an aging population. Even more so than their urban counterparts. For this reason, and also due to the simple lack of needing a new vehicle, respondents may not anticipate ever buying another vehicle, regardless of its propulsion system.

Although when it comes to replacing current vehicles with EVs, 56% of respondents indicated that they do intend to, with a further 27% reporting they will also attempt to get by with less vehicles. This may be due to distrust of the technology, or a conscious attempt to reduce their environmental impact. However, it is very much apparent that everyone in rural areas requires their own private vehicle, 96% reported a lack of local public transport. This is in keeping with UK statistics which show much higher levels of household car ownership (Better Transport, 2018) and drivers licenses (Newman et al., 2014).

Results from the ‘Charging’ section of the survey will now be presented. Figure 5 (a) below shows the availability of parking facilities and type for each respondent, whilst figure 5 (b) presents a comparison between number of vehicles of a household and their expected number of home chargers.

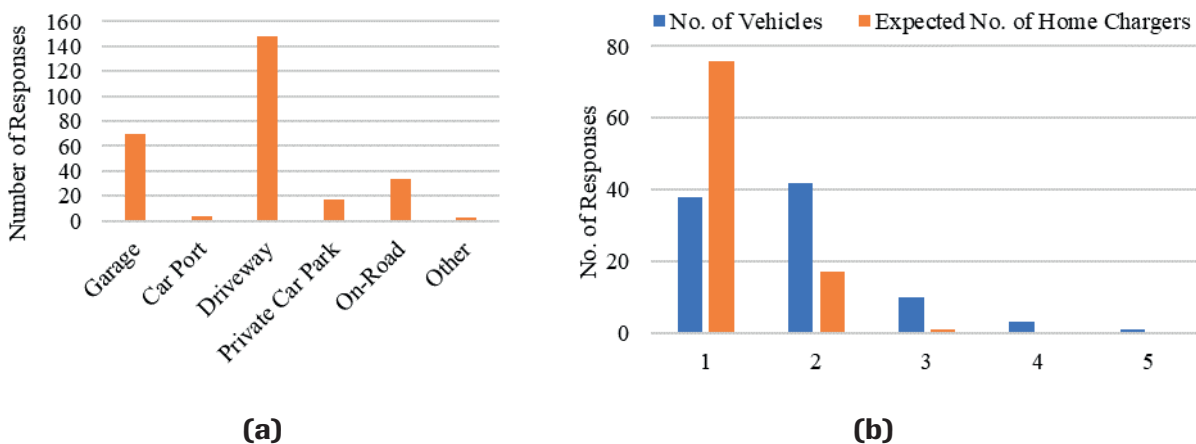


Figure 5: (a) Household parking facilities, (b) Number of vehicles owned by a household and anticipated number of home charge points

As shown in figure 5 (a), very few households have on-road parking, or private car parks away from their houses. These types of parking may prove difficult for EV ownership due to the inability to install a home charge point. Private parking solutions on the other hand, such as a garage or driveway are much more common in rural areas and are ideal for EV charging. Over 67% of respondents are likely to charge their EVs at home. Noting also that 15.6% of respondents actually answered this question with “N/A”. This is likely due to their anticipation of never owning an EV in the future and thus will have no need for charging regardless of the location. When asked about the number of home chargers respondents envisaged having, 62% anticipated one home charge point, 15% two, 1% three, with the remaining respondents split between “I’m not sure” and “N/A”. Firstly, this indicates some lack of knowledge with regards to home charge points with 11% responding with “I’m not sure”, but more importantly this question was raised to investigate the feasibility of individual consumer expectations. Typically UK households are limited to two home charge points (assuming a 7 kW charger), due to the 100A fused incomer. This raises concerns for households with a large number of EV’s as they expect to also install multiple chargers. As shown by Figure 5 (b), survey responses show, whether through their own understanding or not, that households opt for fewer chargers than the number of vehicles they own. Only one household, out of the 192 which responded, owns 3 vehicles, none of which were already EVs, but wished to install three home charge points - an unrealistic possibility. To investigate public charging opinions, the survey enquired to which public areas would be likely EV charging locations participants would utilise. Results are shown in figure 6.

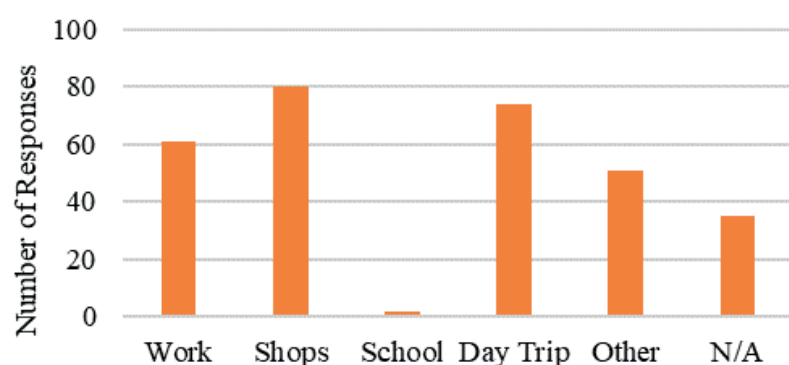


Figure 6: Public Areas likely to charge at

Figure 6 shows all public areas are of high interest amongst the rural community for charging EVs, apart from “School”. This is most likely explained due to school being a largely pick-up/drop-off event, rather than an area one expects to spend a significant amount of time at, unless for instance school was a participants workplace.

The final section of the survey, sought to understand the electricity meters and tariffs of respondents. These are highly entwined factors with the EV transition. The types of electricity meters reported in this survey are shown in Table 1 below.

Electricity Meter	Number of Responses (%)
Smart	38
Standard	28
Variable-rate (Economy 7 or Economy 10)	19
Digital	10
Dial	2
Prepayment	2
Other	1

Table 1: Responses for what type of electricity meter households have installed

EV tailored electricity tariffs are a new product offer by many electricity companies, which follow, more often than not, a similar pricing structure to economy electricity tariffs. They provide cheaper electricity rates during the early hours to encourage EV charging to occur during these times of natural lower electricity demand. When asked about the awareness of these tariffs 64% of respondents were unaware of their existence. The full results can be seen below in Figure 7.

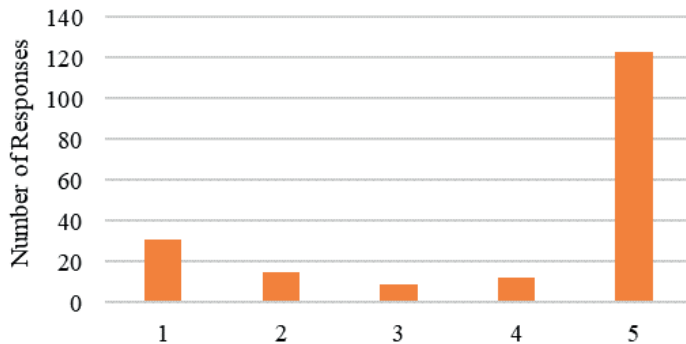


Figure 7: Awareness of EV tailored household electricity tariffs

EV tailored tariffs, in most cases, require a smart meter. For households to qualify for such would require the changing of their electricity meters to a smart meter. From the 192 households, 46% reported that they were open to having a different electricity meter installed, with a further 33% answering “maybe”. The remainder reported “No”. However, this population of households unwilling to change may comprise, in part, of households who already have smart meters installed.

Conclusion

This paper presents the results from an online survey developed to investigate car usage, opinions on EVs and awareness of EV related technologies and legislation. The survey was targeted at rural areas, specifically areas of the Peak District, UK. Results show that individuals in rural areas are open to new technologies and this EV transition, however they do have warranted concerns, vis-à-vis price, range, and applicability. This survey highlights how imperative it is for rural households to own their own private vehicles and given current UK legislation, they will have to convert at some point in the future. However, rural areas offer many possibilities, including the fact that rural areas often have private parking access. This allows for much easier home charging scenarios compared to urban counterparts and the issues faced there. Already there is some adoption of EVs in rural areas, although this remains largely for the multi-vehicle households. Respondents do indicate that awareness is still quite low on technologies that support the EV transition (charge points and EV specific electricity tariffs) but nevertheless, results from the survey presented in this paper provide meaningful data for researchers to utilise in their investigations of EVs in rural areas. The findings are crucial to the practical implementation of future feasibility studies for EVs in rural areas, aiding the real-world transition that has already started. There are multiple implications for policy makers, electrical grid planners, as well as the consumers (the stakeholders of this paper) themselves.

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BLOCK CHAIN ENABLED CIRCULAR SUPPLY CHAINS: A BIBLIOMETRIC ANALYSIS

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Introduction

The growing global interest in the concept of sustainability has intensified the demand for businesses to rethink their conventional approach to the production, consumption, and disposal of goods and services they provide (Yadav et al., 2023). Therefore, it has been becoming crucial for the businesses to revamp their supply chains (Kumar et al., 2019). To express the integration of sustainability notion in supply chain management, several concepts have been introduced and used interchangeably, such as sustainable supply chains (SSCs), environmental supply chains (ESCs), closed loop supply chains (CLSCs), reverse logistics (RL) and green supply chains (GSCs) (Batista et al., 2018; Gurtu et al., 2015). These narratives are connected to the idea of circularity in supply chain management research on a more general level of analysis, but they lack conceptual distinction, particularly in relation to restorative, regenerative and zero-waste vision outcomes (Farooque et al., 2022). According to (Farooque et al., 2019) circular supply chain defined as “the integration of circular thinking into the management of the supply chain and its surrounding industrial and natural ecosystems”.

Transition from linear to circular supply chain brings numerous challenges of tracing and tracking of recycle materials over multiple life cycles across multiple supply chain stakeholders (Wang et al., 2020). Regarding overcoming these challenges, the potential role of technology could be quite substantial. Blockchain technology (BC) is one of the most significant technologies of I4.0. This technology is believed to have or would fundamentally transforms industries and their supply chains (Saberli et al., 2019). As a distributed, decentralised, traceable, and tamper-resistant digital ledger system, BC can assist CSCs in establishing a fully transparent, tamper-proof record system for Information, inventory, and capital flow, thereby assisting all parties involved in the circular supply chain in meeting any challenges that may arise.

The complexity of supply chains and role of BC in circular supply chain transition has attracted the interest of researchers and they have been the subject of number of reviews. Most of the earlier reviews has focused on I4.0 technologies and its operating principles in its broader context. To fill this gap, this study conducted a literature review of pertinent peer-reviewed articles published in the Web of Sciences and Scopus. This comprehensive review provides coherence to the extensive body of research on the nexus of BC and circular supply chain by employing bibliometric analysis along with the strategic mapping and thematic evolution. Additionally, emerging themes can be chronicled as a part of the investigation.

Material and Methods

To investigate and comprehend the theoretical foundation of BC enabled CSC, we consider a systematic literature (SLR) review approach and followed the SLR approach as advised by (Mehmood et al., 2021; Rejeb et al., 2023; Tranfield et al., 2003). The current review consisted of four major steps; 1) the first step is planning the review in which conceptual boundaries are identified, 2) the review specification, where the relevant digital databases and inclusion/exclusion criteria for the literature search is specified.

We collected articles from Web of Science and Scopus, two prestigious scientific databases by using keywords, until March 2023, 3) thirdly relevant articles were selected. The search query was applied in the title, abstract and keyword in Scopus and WOS databases and 585 documents were extracted initially. After filtering the duplicate articles, the sample size reduced to 225. To further filter the pool of publications, the inclusion and exclusion criteria was applied, we were left with 145 studies. The research team conducted the further screening by reading the abstracts, introductions, and conclusions to identify the relevant articles and validate the result. Each member of the research team performed this screening task separately to ensure the highest possible level of neutrality. This yielded a total of 85 articles. The research team thoroughly reviewed the content of these 85 articles. After this rigorous process, further 21 articles were excluded due to lack of focus on BC and CSC specific aspect. Finally, a sample of 65 articles were retained for the analysis of this study. After selecting

relevant publications, the research team compiled their bibliographic information, and lastly 4) the reporting, analysis, and results of SLR were stated. For bibliometric analysis we capture the general information including date of publications and published journals etc whereas for thematic analysis and strategic mapping we use SciMAT.

Results and discussion

Annual Publications

Figure 1 shows the number of articles on the confluence of BC and CSC. In this study 65 peer reviewed articles were analysed, most of which were published in 2022 (34 articles) and 15 in 2021. The significant increase in the number of publications in the year 2022 demonstrated that the academic interest in the subject has skyrocketed which makes it more reason why a thorough review of the literature should be done at this time. In addition, the authors arrive at the conclusion that the expansion of sustainability standards in supply chains was the primary factor that contributed to this increase in publications.

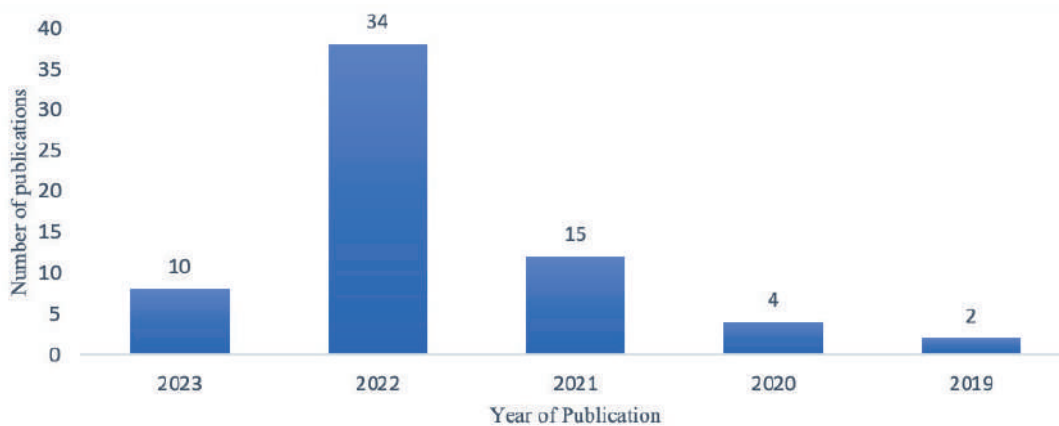


Figure 1. Articles Published per Year

Percentile Research Contribution by Industry

Figure 2 presents the percentage contribution of research publications in various sectors. The analysis stated that significant research has reportedly been conducted in the manufacturing (24%), food (18%), and energy (15%) sectors, and the focus of research is now shifting to the healthcare (10%), fashion (9%), and agriculture (8%) sector.

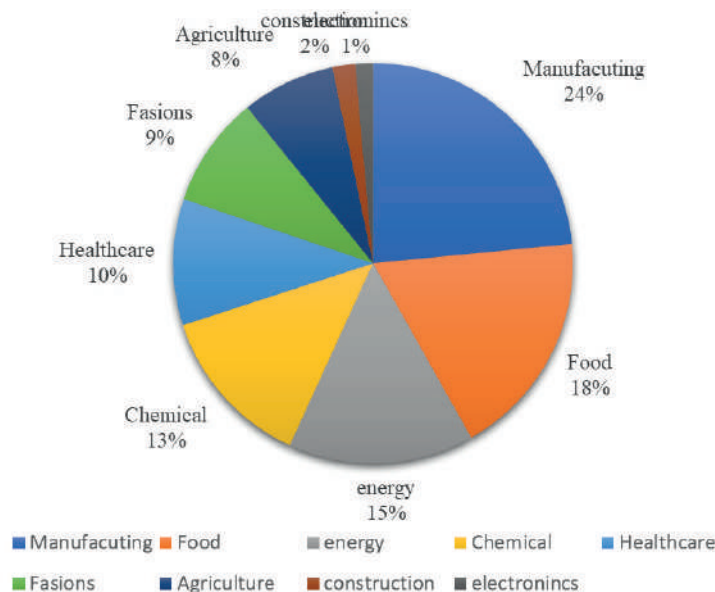


Figure 2. Percentile Research Contribution based on Industry

Most Influential Sources

Figure 3 presents the 11 most relevant publication sources. It shows the number of articles published by each journal relevance to BC and CE in supply chain management. The data depicts that the Journal of Cleaner Production was at the top of the list with 7 publications, followed by Business Strategy and the Environment, Computers and Industrial Engineering, Industrial Marketing Management, Sustainable Production and Consumption, Sustainability, Benchmarking, Journal of Enterprise Information Management, International Journal of Production and Planning.

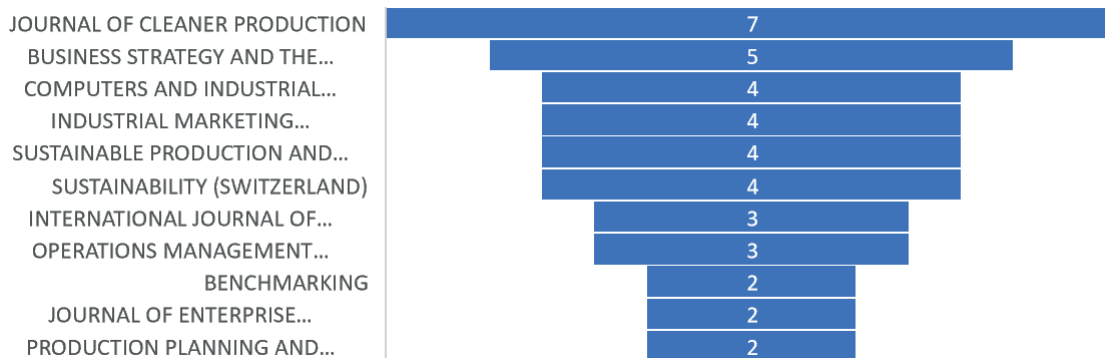


Figure 3. Most Relevant Publication Source

Co-occurrence by keywords

To narrow down potential research topic a keyword co-occurrence analysis is commonly used (Wang et al., 2019a). The co-occurrence of authors' keyword network was constructed with the criterion that a keyword must appear in at least five papers for the analysis. Out of 557 keywords 103 meet the threshold. There were 7 distinct cluster found. The Circular economy is the most prominent node and showed a significant association with block chain, supply chain management, sustainability, and circular supply chain with occurrences of 48 times, 102 links and total 332 link strength. The findings revealed robust connections between topics such as circular economy, supply chain management, sustainability, and block chain. Other prominent keywords were industry 4.0, circular supply chain, traceability, transparency, product design and sustainable supply chain as shown in the figure 4.

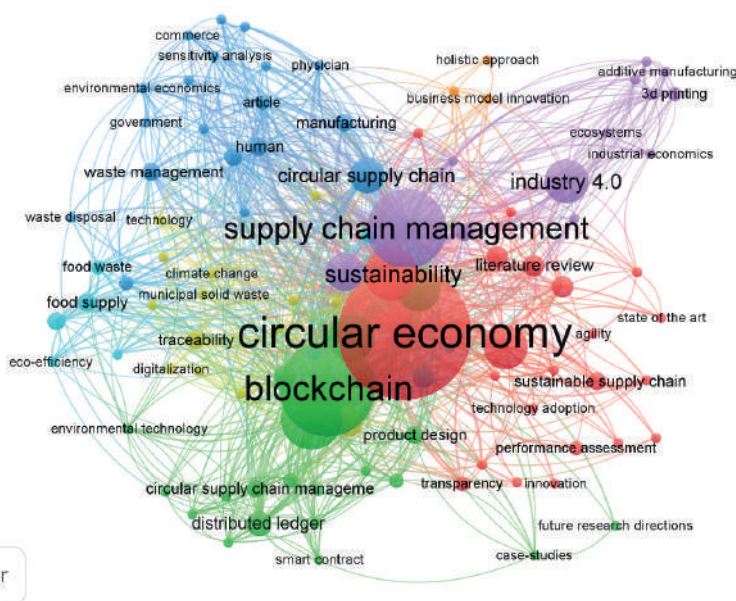


Figure 4. Co-occurrence by keywords

Thematic evolution

In this section we highlighted the evolution of various research themes within the BC_CSCs domain. To achieve this, SciMAT is used, it allows the longitudinal examination of scientific mapping by dividing the time into distinct subperiods. The first step is to trace the development of study fields over a certain period. From there, we identify the most significant evolutionary trends, their antecedents, and the connections among them.

The key themes are highlighted in a strategic diagram from 2020 to 2023; the year 2019 has been excluded since we were unable to identify any topics specifically relevant to our research domain. Centrality measures the degree of interaction between networks. Density, on the other hand, measures the inner strength of the network. The size of the spheres represents the number of published articles on a particular research theme.

As can be seen in figure 5, there has been an increased focus on sustainable development in recent years, and this trend has reached to its peak in 2022, providing conception to new themes like AI, smart contracts, circular supply chains, and traceability. Our results show that the term block chain appears at the centre of the first and second quarter in 2020 and moved to the far right of the fourth quarter and is about to move to the first quarter in 2023 which indicates research interest in BC is gaining momentum but still immature. The term circular supply chain appeared only in 2021 and 2022 in conjunction with sustainable development which shows that the relationship between BC and CSCs has not been fully explored. In addition, figure 5 shows how our primary research focus has evolved and how it has been related to other themes.

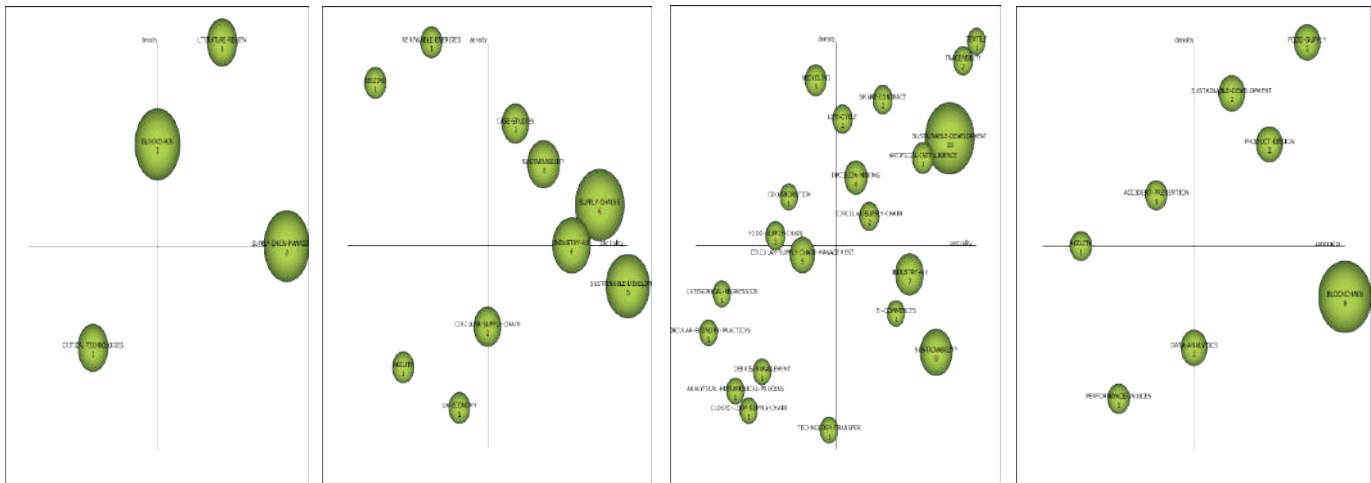


Figure 5. Strategic diagram from 2020-2023

The yearly evolution of key research themes is given in table 1, depicting the number of documents, number of citations, and h-index for each theme. In 2020, more than 200 citations were made to the blockchain, but by 2021–2022, the topic had faded from popularity. During this time, we regarded the blockchain to be an embedded theme in I4.0; nevertheless, in 2023, it is once again becoming a popular theme. In 2021, researchers have been particularly interested in the supply chain, sustainable development, and I4.0 themes. In 2022, circular supply management replaces the traditional supply chains as a key theme of study alongside sustainable development and Industry 4.0.

Key Themes	Number of Documents	Number of Citation	h-Index
2020			
Blockchain	2	282	2
Supply chain management	2	138	2
2021			
Supply chains	6	314	5
Sustainable development	5	281	4
Industry-4.0	4	243	4
Circular supply chain management	2	26	2
Seizing	1	29	1
2022			
Sustainable development	19	317	10
Industry-4.0	7	84	5
Circular supply chain management	7	101	5
Artificial intelligence	3	82	2
Smart contracts	2	93	2
2023			
Blockchain	8	8	2
Sustainable development	2	1	1
Food supply chain	2	1	1

Table 1. Evolution of Key Themes

Conclusions

This study presented the state-of-the-art research to explore the relationship between BC and CSCs. Our findings demonstrated that the expansion of sustainability standards in supply chain was the primary factor that encouraged the increase in publications. We also provide an overview of the current trending articles in the research domain which is necessary to identify the works that have had the most significant influence on the BCT_CSC literature. We have demonstrated how bibliographic mapping technique can be used to highlight the current and emerging themes in the last five years. The research findings highlighted that the BC, sustainable development along with circular supply chain were the emerging themes along with artificial intelligence and food supply chains. Additionally, the analysis shows that the research on BC and CSCs is dispersed among various academic discipline, sectors, and countries. Which demonstrates the multidisciplinary conception of the research domain. This study will help researchers to focus on the emerging theme and relevant trends for a specific sector of the economy.

Despite its useful findings, the current study has several caveats that could be addressed with further research into similar works. The study is restricted to academic articles that were found on Scopus, Web of Science, and Google Scholar search. The review did not include books, book chapters, conference papers, and reports. A broader range of sources, such as books, book chapters, and conference papers may be considered by future scholars. Despite its shortcomings, the current SLR has provided a detailed investigation of BC's involvement in the CSCs and new patterns at this nexus. Future academic investigations in this field are likely to substantially depend on the present review.

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LOGISTICS SERVICE QUALITY IN E-COMMERCE: A STUDY IN INDIAN PERSPECTIVE ON CUSTOMER SATISFACTION AND LOYALTY

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Abstract:

Purpose: In e-commerce, the customers and the sellers are distant and can't interact face to face regarding their likings and dislikings about the product, delivery quality, buying experience, etc. This results in an absolute need for e-commerce companies to measure customer satisfaction and loyalty to grow and sustain in the competitive business world. At the same time, due to the delivery of products to the customer's doorstep, the perception of the customers towards logistic service quality becomes even more important.

Research Approach: The available pieces of literature fail to sufficiently explain the relationship between e-commerce logistics service quality, customer satisfaction and customer loyalty, especially in the Indian context. This study aims to explain the same through a Structural Equation Model encompassing different factors connected with the quality of e-commerce logistic service. Findings and Originality: Considering the above factors, this study is the first of its kind which addresses Indian e-commerce customers. The finding shows the significant effects of logistics service quality factors like order accuracy and order discrepancy handling on customer satisfaction. This study also indicates a significant impact of customer satisfaction on customer loyalty.

Practical Implications: This study reveals the impact of different logistics service quality on customer satisfaction levels and further customer loyalty. This study is expected to help e-commerce companies to allocate resources suitably on different factors influencing logistics service quality, which in turn is expected to help them to grow and sustain in a competitive business environment.

Key Words: e-commerce, Customer satisfaction, Customer loyalty, Structural Equation Model

Introduction

Technological advancement has made human lives easier, and the inventions and rapid use of the internet are the keys to modern human lives. The concept of 'Industry 4.0' depends entirely on networking and the internet. This internet also brings new business opportunities in the form of e-commerce. With a lower tariff structure for the internet, smartphone users also grow rapidly in India. The number of smartphone users in India, which used to be 750 million in 2021, is expected to reach 1000 million by 2026¹. Such a large number of users boost the growth of e-commerce in India. In 2020, India became the eighth-largest e-commerce market, with a turnover of around US\$ 74.8 billion¹.

The Covid-19 pandemic, which resulted in lockdowns and restrictions, also boosted the growth of e-commerce. Due to movement restrictions induced by Covid-19, there was a massive increase in online retail sales share of total retail sales from 16% to 19% in 2020².

¹ E-commerce industry report, February 2022 by India Brand Equity Foundation

² Source: <https://unctad.org/press-material/global-e-commerce-jumps-267-trillion-covid-19-boosts-online-retailsales> accessed on 08.05.2023

The logistics performance of an organisation has been viewed as a strategic factor playing a key role towards customer satisfaction (Gil et al., 2010). Various studies suggest that the quality of logistics services contributes to customer satisfaction (Akil et al. 2021). On the other hand, various studies have identified factors concerning logistic service quality. The present study considers the leading factors of logistic service quality, as identified by Akil et al. (2021), viz., (i) timeliness, order condition, order accuracy and order discrepancy handling.

Odunlami (2016) identified customer loyalty as a function of customer satisfaction. In the present competitive business scenario, acquiring new customers is more expensive and time-consuming than retention of existing ones (Javed & Wu, 2020). Therefore, retaining existing customers is expected to sustain any business's growth.

This study investigates to what extent e-commerce logistic service quality factors, as mentioned above, influence customer satisfaction. It also examines whether customer satisfaction influences customer loyalty towards a specific e-commerce platform. Such a study has already been carried out among e-commerce customers in other countries. But such an attempt is scanty in the Indian context.

Theoretical Framework

Logistics service quality

Logistics service quality (LSQ) has been defined by Yang et al. (2010) as a set of performance factors measured by the ability to distribute products as per customer requirements. In the case of online shopping, from the customers' perspective, the logistics service spans from placing an order to finally delivering the same (Choi et al., 2019). The delivery of goods or services is seen as the most important part of e-commerce (Yazdanifard et al., 2011).

With the increasingly competitive environment in online retailing (Rezaei et al., 2014), e-commerce platforms tirelessly attempt to improve the customers' buying experience. Logistics service quality is the key driver for creating value and gaining a competitive advantage (Stank et al., 2003; Mentzer et al., 2001). The logistics service quality of a company can differentiate itself from its competitors (Bowersox et al., 1995; Kyj and Kyj, 1994; Leuschner and Lambert, 2016). Logistics service quality is a key factor in creating customer satisfaction, which has a major impact on customer loyalty (Vasić et al., 2021).

Factors responsible for logistics service quality

- i. **Timeliness:** Time is one of the extremely valuable factors to most individuals in their lives. Accordingly, the timely delivery of goods and services is viewed seriously by many e-commerce platforms.
- ii. **Order condition:** The goods ordered by a customer need to travel through a number of handling processes and may include multimodal transportation before it is delivered to him. Hence, the goods may get damaged during such transportation unless properly protected.
- iii. **Order accuracy:** According to Politis et al. (2014), order accuracy is whether the delivered products are the correct ones with the correct quantities. Order accuracy is a dimension related to the accuracy of the courier service for orders taken from customers.
- iv. **Order discrepancy handling:** Order discrepancy handling refers to how the logistics service provider addresses any discrepancy in order after the orders arrive (Mentzer et al., 2001). The performance of the logistics service provider towards correcting the discrepancies impacts customers' perception of the logistics service quality of such service provider (Mentzer et al. 2004). According to Ramanathan (2011), handling the product return has an essential role in influencing a customer's loyalty. A significant positive relationship is seen between properly handling order discrepancies and customer satisfaction (Gaudenzi et al., 2020)."

Customer Satisfaction

The American Society for Quality has defined 'customer satisfaction' as a measurement that determines how happy customers are with a company's products, services, and capabilities³. According to Gaundazi & Russo (2020), customer satisfaction and service quality are related concepts. Customers get satisfied or even delighted with exceeding service performance compared to expectations (Juga et al., 2010). The term customer satisfaction usually indicates the level of happiness of a customer towards a company's products, services and capabilities. A higher level of customer satisfaction has been linked to improving an organisation's economic returns, including market share and profitability (Anderson et al., 1994; Crosby et al., 1990; Leuthesser and Kohli, 1995). Several studies support that improving logistics service quality can increase customer satisfaction (Leuschner et al., 2016). Logistics service quality has positively impacted customer satisfaction (Suresh et al., 2021).

Customer Loyalty

Customer loyalty refers to the positive view of a customer towards a specific service provider regarding certain services and his intention to use similar services from that particular service provider only as and when required. In the case of e-commerce, customer loyalty becomes a crucial success factor for a company's long-term sustenance and profitability (Wu & Li, 2018). Ramanathan (2010) argued that the relationship between logistics performance and e-commerce customers is much closer than in any other industry. According to IBOJO & Odunlami (2015), a customer's loyalty towards an organisation results from satisfaction from consumption and uses of goods or services received from the organisation. True customer loyalty is created if a customer advocates for the organisation, even without an incentive (Oliver, 1997).

The relationship between customer satisfaction and customer loyalty

Customer satisfaction and loyalty are two aspects of customer behaviour that every organisation intends to achieve (El-Adly, 2019). The level of satisfaction or dissatisfaction of the customers may get manifested through their future behaviour. While a satisfied customer is expected to purchase again from the same seller and even advocate for the products or services of the firm, a dissatisfied customer may stop buying from the seller and even may express dissatisfaction to others. It was suggested by Luo et al. (2020) that e-commerce platforms need to increase levels of customer satisfaction and thereby encourage customers to adopt more positive post-purchase behaviour.

Several studies explained the relationship between customer satisfaction and customer loyalty. Narayandas (2005) opined that companies should develop positive relationships with customers, and thereby, customer loyalty can increase over time. Gautam & Sharma (2021) argued that customer satisfaction directly impacts customer loyalty. Choi et al. (2019) in their study stated that there is a linear relationship between customer satisfaction and repurchase intention.

Hypothesis

Based upon the aforesaid theoretical framework, the following hypotheses are framed.

H1: Perception of 'timeliness' positively impacts customer satisfaction.

H2: Perception of 'order condition' positively impacts customer satisfaction.

H3: Perception of 'order accuracy' positively impacts customer satisfaction.

H4: Perception of 'order discrepancy handling' positively impacts customer satisfaction.

H5: Customer satisfaction has a significant positive impact on customer loyalty."

3 Source: <https://asq.org/quality-resources/customer-satisfaction> accessed on 09.05.2023

Materials and Methods

Sampling and Data Collection

As the target population, i.e., the online buyers, are scattered throughout India, an online survey was conducted in May 2023. For the purpose of collecting data, conveyance sampling with a 'chain referral' approach was followed. Data were collected from 113 respondents."

Tools used for Assessment

Data were collected through a questionnaire consisting of items on; socio-demographic aspects, the impact of timeliness, order condition, order accuracy, and order discrepancy handling, as these factors are considered leading logistics process factors by Akil and Ungan (2021). Apart from this, the questionnaire consists of items on customer satisfaction and loyalty levels. Other than questions on the demographic profile of the respondents, all items were measured through the Likert scale."

Questionnaire: Internal Consistency And Validity

The reliability and validity of the instruments were also tested, and items that failed to be valid were excluded from the final questionnaire. The confirmatory factor analysis (CFA) was carried out. Items with a factor loading of 0.50 and above are considered and included."

Results

Demographic profile of the respondents

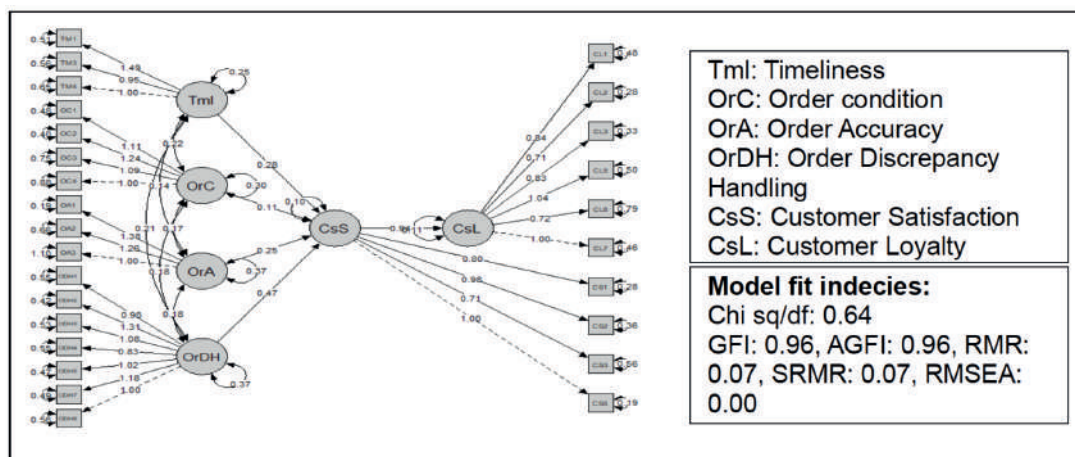
The demographic profile of the respondents is shown in Table 1 below.

Educational Qualification				Occupation				
Class 12	Graduate	Post Graduate	Ph.D.	Service	Business	Self Employed	Retired	Student
2	36	66	9	66	3	10	5	29
Age (in years)								
<21	21-25	26-30	31-35	36-40	41-45	46-50	>50	
1	37	26	15	10	3	8	13	
Gender			Marital Status					
Male		Female	Married		Unmarried		Divorced/Widower	
92		21	47		65		1	

Table 1: Demographic profile of the respondents

Impact of Logistics Service Quality on Customer Satisfaction and thereby Customer Loyalty

The present study measures the logistics service quality in four different parameters, viz., timeliness of delivery, order condition, accuracy in order delivery and handling of order discrepancy. On the other hand, customer satisfaction and loyalty are also measured. A Structural Equation Modelling with a path model is carried out based on the collected data, and the outputs are shown in Model 1 and Table 2 below.



Model 1: Path model – Impact of logistics service quality on customer satisfaction and loyalty

	Estimate	Std.Err	z-value	P(> z)	std.lv	std.all
CustomerSatisfaction ~						
Timeliness	0.282	0.384	0.733	0.463	0.226	0.226
Order Condition	0.112	0.272	0.410	0.682	0.099	0.099
Order Accuracy	0.250	0.095	2.633	0.008	0.244	0.244
Order Discrepancy Hand	0.466	0.141	3.300	0.001	0.455	0.455
Customer Loyalty ~						
Customer Satisfaction	0.944	0.090	10.456	0.000	0.870	0.870

Table 2: Regression coefficients of factors of logistics service quality (independent variables) on customer satisfaction (dependent variable) and thereby on customer loyalty (dependent variable)

Based on the above Model 1 and Table 2, the status of the formulated hypotheses is shown in Table 5 below.

Hypothesis	Significance	Result
H ₁ : Perception of 'timeliness' positively impacts customer satisfaction.	0.46	Not supported
H ₂ : Perception of 'order condition' positively impacts customer satisfaction.	0.68	Not Supported
H ₃ : Perception of 'order accuracy' positively impacts customer satisfaction.	0.00	Supported
H ₄ : Perception of 'order discrepancy handling' positively impacts customer satisfaction.	0.00	Supported
H ₅ : Customer satisfaction has a significant positive impact on customer loyalty.	0.00	Supported

Table 5: The summary result of the hypotheses

Result Analysis and Discussion

This present study is probably the first of its kind, which addresses Indian online customers' perception towards different factors associated with logistics service quality and their impact on customer satisfaction. It also addresses whether the satisfaction levels among Indian customers buying online impacts their customer loyalty.

In the present study, the standardised regression coefficient is 0.23, which does not reveal a significant impact of timeliness on customer satisfaction. Such a finding contradicts previous studies, which found a significant impact in this regard (Otim & Grover, 2006; Uvet, 2020; Vasić et al., 2021; Akil et al., 2021). But on the other hand, this finding supports the finding of a previous study by Luo et al. (2020), which states that the time-effectiveness of logistics service does not positively impact customer satisfaction.

The present study doesn't find a significant impact of order conditions on customer satisfaction. Such a finding doesn't comply with previous studies, which found a significant positive relationship between order condition and customer satisfaction (e.g., Uvet, 2020; Akil et al., 2021).

Order accuracy with a regression coefficient of 0.24 has been seen to impact customer satisfaction significantly. This finding complements previous studies (Bienstock et al., 2008; Chaisaengduean, 2019; Akil et al., 2021). This implies that the delivery of proper items with the right quantity and quality leads to satisfied customers, while the absence of such leads to customer dissatisfaction.

Order discrepancy handling with a standardised regression coefficient of 0.46 significantly impacts customer satisfaction. Such a finding is in line with the findings of previous studies (Akil et al., 2021) but, at the same time, contradicts the finding of a study by Sutrisno et al. (2019) and Uvet (2020). It may be noted here that order accuracy and order discrepancy handling affect overall satisfaction may differ by country or region due to different levels of tolerance toward errors (Mentzer et al., 2004).

In the present study, customer satisfaction has a significant positive impact on customer loyalty. Such a finding implies that for online buyers in India, loyalty towards a particular e-commerce service provider is positively influenced by customer satisfaction. This finding complies with previous studies (Sutrisno et al., 2019; Akil et al., 2021).

Conclusion

This study is based on data provided by Indian e-commerce customers regarding their perception towards e-commerce logistics service quality, customer satisfaction and customer loyalty. While the brick-and-mortar model allows the sellers to interact with the buyers face-to-face frequently, the same is not possible in the case of e-commerce. On the other hand, reverse logistics in case of the return of goods is time-consuming for the customer and costly for the company. This study attempts to shed some light on whether different logistics service quality factors impact the satisfaction level of customers. It also throws light on the impact of customer satisfaction on customer loyalty. As this is probably the first study of its kind on a population living in India, this study develops a theoretical framework which may be used as a stepping stone for further research. The e-commerce companies, on the other hand, can use this study to identify success factors which may help them build winning strategies in developing customer satisfaction through better logistics service quality and thereby increase the number of loyal customers.

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DETECTION OF UNDERVALUATION OF IMPORTED GOODS AT CUSTOMS

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Introduction

Undervaluation of imported goods – which occurs through error or fraud to avoid customs duties and VAT – is a challenge with many dire consequences (Erkoreka, 2020). For example, undervaluation causes a significant loss of revenue to governments. In addition, local manufacturers face unfair competition from fraudulent imports that do not pay tariffs, which may threaten their survival and endanger the national economy. Furthermore, governments may be at risk of legal liabilities from their trade partners. For example, in 2018, the European Commission fined the UK 2.7 billion for not collecting the correct customs duties on imports from China (EU-Commission, 2022; Rankin and Boffey, 2022). Moreover, delays and disruptions of supply chains occur when customs authorities hold imported goods that they suspect as undervalued.

Besides customs authorities, organisations involved in importation, such as customs brokers and logistics operators, are keen to mitigate the challenges associated with the undervaluation of imports. The mitigation will engender transparency and trust in the domain, avoid disruptions of supply chains, help them stay compliant with international legislation and avoid consequences like losing their reputation and operating licences.

Currently, the undervaluation of imports is hard to detect for many reasons (Cathey et al., 2018). First, the sheer volume of today's importations and the current approaches that rely on intense manual intervention and human expertise makes it impossible to check all declarations. In addition, determining an acceptable price for many categories of goods is complex, and the terrain is fluid. For example, the value of a pair of shoes may range from £1 to £1000 based on many features. Yet the estimation of prices for shoes and textiles is sometimes done by their tonnage. Furthermore, highly motivated actors are evolving ways to obfuscate the pricing and evade tariffs. Therefore, an automated artificial intelligence (AI) based system for detecting undervaluation will be beneficial.

Central to such an automated system of detecting undervaluation is reference data that will form the basis for statistically determining if a declared value is reasonable (Jain et al., 2020). However, challenges are associated with obtaining reliable and publicly available data, such as its reliability and availability. For example, the price of the items may fluctuate, and historical data may contain fraudulent values. In addition, many customs authorities do not make publicly available the raw and granular data that include the declared value.

This study aims to determine whether undervaluation is detectable with automated systems that use publicly available data. Therefore, after examining several options, this study found that e-commerce websites are a source of suitable data, which includes reliable pricing and other relevant information. In addition, it meets other criteria that improve the viability of the solutions that will leverage the data; they include being dynamic and up-to-date, having little or no cost, and having no overreliance on other parties.

We developed and tested a methodology for automatic data collection from e-commerce websites. It involves transforming the data using contextual knowledge before being loaded into a database. Furthermore, since customs use the international Harmonised System for classifying traded products to identify items (HS Codes), we developed a machine learning model for assigning HS codes to the samples of data collected. Industry experts validated the HS Code assignments. Finally, we analysed the database for suitability of purpose – ability to predict prices of goods.

2. Background

This study focuses on the role of customs as the guardian of the gateway to the national economy. Studies show that the scale of the customs fraud problem is difficult to estimate but is considered extensive (Erkoreka, 2020; Cathey et al., 2018). Still, the figures involved in international trade are huge; therefore, the incentives for fraud are attractive, and mitigating it is compelling. According to the UK Office of National Statistics (ONS, 2023), the value of the UK's trade (goods and services) in the 12 months ending April 2023 is £1,743 billion, and imports of goods account for £896 billion.

Import duty or tax is calculated based on the product type, the value, the value de minimis level (threshold before tariffs apply), and the origin (via trade agreements). Therefore, to avoid import duty, import declarations can be deliberately misclassified, undervalued, and the origin of goods falsified; undervaluation is arguably the more common device. Further, due to the volume of imports, the inspection and verification of every import is impossible manually.

A fundamental approach to managing fraud and security challenges in international trade is to use Risk Management (RSM) frameworks. Some involve assessing and profiling risks to enable informed decision-making regarding focus areas and the allocation of resources (Drobot et al., 2017). The framework that European Union (EU) uses is the Customs Risk Management Framework (CRMF), which includes Common Risk Criteria (CRC) and Standards that define financial and security risks criteria. Further, the CRMF maintains the Priority Control Areas and allows for the coordinated exchange of risk information amongst members. Studies show that RSM works when combined with other approaches but maintaining a balance between risk management and facilitating effective trade is delicate (Too, 2021, Drobot et al., 2017). Furthermore, involving stakeholders in the decision-making is beneficial. Thus, the use of risk management framework is an involved process that is continuously refined.

The recognition of how technology may help mitigate the challenges for customs is not new. However, the implementation is not straightforward, and barriers exist, which include technical constraints, costs, quality, and trust (Urciuoli et al., 2013). The literature shows there is a drive towards leveraging recent data science approaches. For example, Chen et al. (2021) used machine learning to detect the misclassification of goods for tariff code circumvention. ZhuchNov and PashNo (2021) reviewed the reliability of under-invoicing revealing methods, including Mirror Analyses, which seek to reconcile import declaration data of a country with exports reported by its partner countries, and Price Filter Method, which is a bottom-up technique which approximates a price filter for each commodity and applies it as a proxy for arm's length prices. These types of approaches work best in more heterogeneous categories of goods.

A further example is the price referencing tool employed by South African Revenue Services to address the undervaluation of imports. The analysis of the price referencing tool shows that challenges arise, which introduces disadvantages that compete with the advantages (Mansoor, 2014). One of the challenges is setting the basis for the reference price per tariff heading, especially for non-heterogenous categories like clothing and textile. This study strives to secure and evaluate reliable data that can statistically predict the plausibility of the value of import declarations and for building AI-based systems for detecting undervaluation.

3. Methodology

3.1. Determining a Suitable Source of Data for the Detection of Undervaluation

To determine suitable features that will comprise the database, we analysed the data flows of customs operations and critical data pathways for calculating and checking the integrity of the value of imports. Due to unavailability of suitable official customs data for the imported goods, we identified self-collecting from e-commerce websites programmatically (also known as web scraping) as it offers up-to-date data at little or no cost, is scalable, can be done independently, and can be fully automated. Furthermore, it allows the customisation of the constitution (features) of the data although it requires some pre-processing to standardise its format. Moreover, the research showed that literature and open-source tools exist to enable collect and process it (Cathey, 2018).

3.2 Automated Data Collection with Web Scraping

The data collection process simply reads and captures relevant contents of a webpage, as known as web scraping. In other words, it automates what a person may do: search for a product type and then copy and save the details and prices from the result of the search. Web scraping has an established precedence and, therefore, ample literature and open-source tools are available (Karthikeyan et al., 2019; Khder, 2021; Singrodia et al., 2019).



Figure 1: Overview of web scraping

3.3. Data Curation and HS Code Assignment

The data collected through web scraped is semi-structured and needs transformation before loading to a database. Pre-processing and transforming the data values requires contextual knowledge. In addition, given that the customs declarations use the worldwide Harmonised System of Commodity Codes (HS) to identify the goods, each instance of data needs to be assigned an HS code, which enables querying the database by HS code. To that end, we developed a machine learning model that learns from examples and then assigns appropriate HS codes to each instance of the collected data.

3.4. Overview of the Proposed Data Collection Method

As the data source of choice needs to be collected and curated, developing and testing a methodology for the process is essential. The methodology has six phases, which are summarised in Table 1; further details are provided in Section 4.

Table 1: Overview of the Data Collection Methodology.

	Phase	Actions
1	Define Query	- Identify import goods category (HS chapter). - Identify e-commerce web sites. - Define and test queries for the websites. - Identify the data fields to collect.
2	Collect Data	- Setup tools to collect the data using the queries and data fields. - Automate collection (should navigate multiple result pages).
3	Extract, Transform, Load	Use bespoke programming, scripts, and tools to clean and standardise the data.
4	HS Code Labeling	Use machine learning to assign appropriate HS codes to each item in the data.
5	Validate	- Perform quality checks on the collected data. - Use human experts and tools to validate.
6	Analyse	Analyse the data to determine its suitability

4. Experiment:

For testing the proposed methodology, we used footwear items -- a category of goods whose price is notoriously difficult to estimate and prone to undervaluation; footwear is one of the categories of goods flagged in the European Union and UK dispute (Rankin and Boffey, 2022).

A key aim is to automate the process to enable periodic updating of the database. Therefore, the configurations, such as data cleaning, are robustly defined.

Brief descriptions of the experimental configurations are as follows:

1. Definition of search queries: To ensure a broad representation of diverse goods of the category, we used keywords from the HS Code classification system to define multiple queries. The keywords for footwear include 'sportswear', 'purposes', 'metal toe cap', and 'upper' or 'sole' (leather, textile, rubber, or plastic material). Twelve queries were sufficient for configuring the automated data collection for footwear data from AliBaba.com.
2. Data retrieval: This study used open-source tools to retrieve data automatically (web scraping). They are Web Scraper (a Google Chrome add-on) and Scrapy (available as a Python library).
3. Extract, Transform, Load: Based on contextual understanding, we programmatically define a system that cleans, standardises, and extracts features before putting them into the appropriate data fields.
4. Machine Learning for Assigning HS Codes: We built a machine learning tool with the decision tree algorithm to automatically assign appropriate HS Codes to all the instances of the collected data.

The main challenge of building the machine learning (ML) model is pre-processing the collected data to distil attributes (features) that determine the HS code according to the HS classification system.

The process for building the HS Code classifier is as follows:

- i. Identify the features that determine classification using the HS classification system.
 - ii. Collect and extract data that can distinguish the HS codes
 - iii. Pre-process the data to standardise the values.
 - iv. Manually created samples for the algorithm to learn from
 - v. Train an ML model to learn to assign the correct label.
 - vi. Test and verify.
5. Validating HS code assignments: expertise from an internationally established customs clearance company validated the results of the data labelling random samples.
 6. Analysis of the Results and Findings

This section summarises the analysis of data collected and curated with the proposed methodology. This analysis aims to answer central questions. First, to determine whether meaningful differences exist between HS codes in the data, which will indicate the data's usefulness for estimating the price. Second, to determine whether the prices of items with the same HS Code can vary significantly with other features of the data (e.g., brand, origin) to allow for a more targeted price estimation. Positive results indicate a promising prospect for the proposed AI-based system that will use the data.

6.1. Summary of the Collected Data

The test yielded 12,212 samples of footwear, parts for making footwear, and footwear accessories. Some features were retrieved as-is, and others were derived (e.g., from the description). The features include those that determine the HS Codes of the items, the HS codes, the product description, and the link address to the product page. In addition, the features include other attributes that may help distinguish items of the same HS Code to provide a more targeted prediction of their prices, for example, the brand, gender, and origin.

In the dataset, the average prices of HS Codes vary between \$4.67 to \$107.61. Similarly, the standard deviation, which indicates price variation within the groups, ranges from 4.02 to 98.74. Furthermore, some HS Codes occur more frequently than others. Some differences are explainable; for example, leather shoes with leather soles (640420) are less frequent than those with synthetic soles (640411).

These following analyses the differences between the prices by HS codes to determine if the data will estimate the accurately predict the normal ranges. The boxplots in Figure 2 show significant differences in prizes by HS Code. Some explainable differences are the following examples:

- Leather shoes (640510) have higher prices with higher variance (mean: 42.24 and std: 39.64) than shoes made with textile material (640520) (mean: 7.04 and std: 9.44).
- Leather shoes with leather soles (640351) have higher prices on average (mean: 107.61 and std: 98.74) than leather shoes with synthetic soles (640391) (mean: 32.55 and std: 53.38).

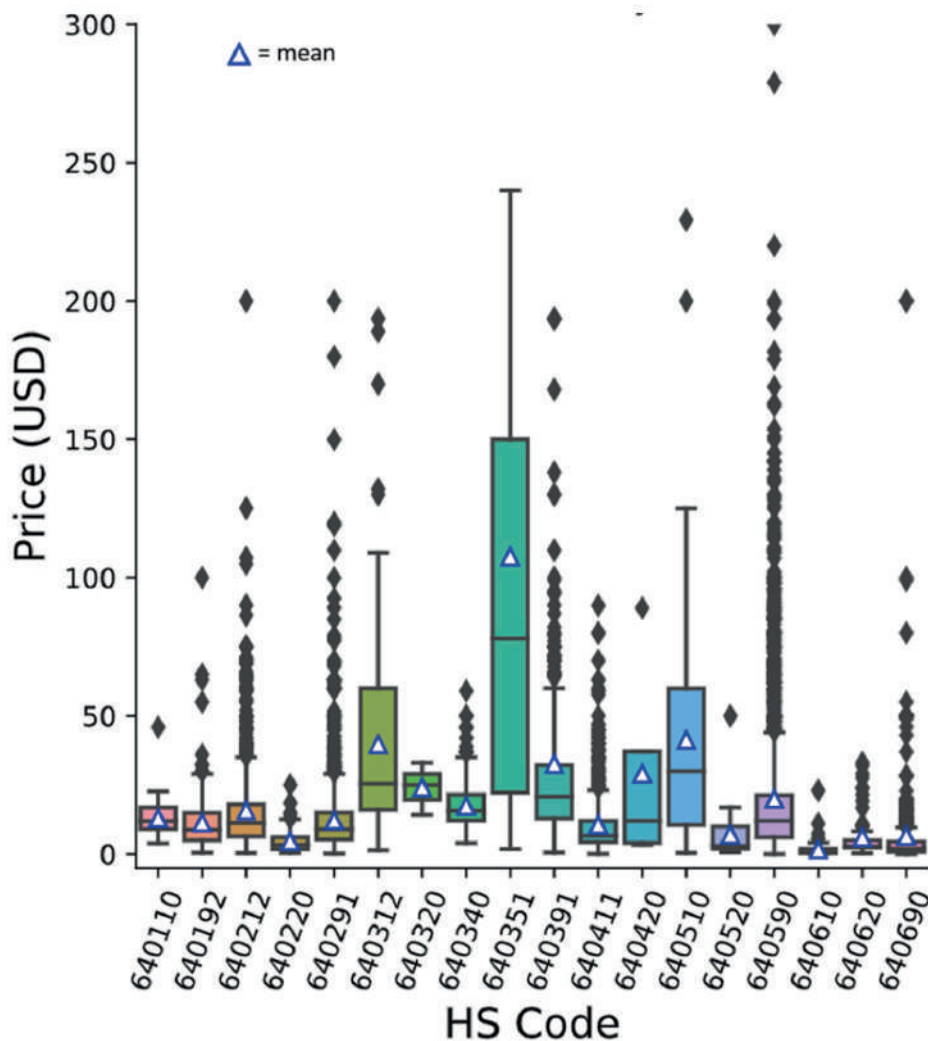


Figure 2: Boxplots showing the distribution of price of footwear items by their HS Code.

The boxplots in Figure 2 helps to illustrate the 'normal' pricing ranges; the proposed solution will check if a declared value of an item is plausible. The outliers (black dots) represent extreme values at both ends of the scale that can distort the estimate of an acceptable price range for the HS Code. Therefore, focusing on the non-outliers is consequential.

The boxplot indicates how statistical methods may determine if a price falls within a reasonable range. For example, a less stringent consideration of an acceptable price range may be one that disregards the outliers (extreme values) only, and a stringent one may use the middle 50% (between the lower and upper quartiles).

5. Conclusion and Future Work

This study established that building a database for producing automated systems to detect undervaluation is achievable at scale and viably. After reviewing various sources, we found that e-commerce websites contain rich data that can make up a database suitable for AI-based applications. Therefore, a methodology for collecting and curating data and extracting new features for enrichment was developed and tested. Analysis of the collected data shows that it estimates the value of goods by their HS codes, and other features (e.g., brand, country of origin, gender, purpose of the shoe (sports/casual/safety)) can offer more precision.

The innovations include a methodology that automatically collects and curates purpose-fit data from e-commerce websites, a dataset that constitutes pricing and other information (20+ attributes and 12,212 data samples) of footwear from e-commerce websites, a machine learning (ML) model for assigning HS codes, and illustration that the database can estimate the value of goods. Moreover, this study identified the essential data attributes by analysing the critical data pathways and HS code descriptions to define the features of the data.

Building on the outcomes of this study will help governments mitigate internal revenue leakage and reduce the risk of potential fines from international trading partners for allowing unfair and anti-competitive practices to occur. In addition, it will enable customs clearance to provide cost-effective, time-efficient and quality services and prevent delays from post-clearance audits and financial penalties for non-compliance. Furthermore, it will help the stakeholders increase their trustworthiness and reputation by contributing to transparency in customs processes.

Future work can expand the automated data collection system to include the remaining categories of goods from the HS classification system. As the study indicates that the features of the database built from e-commerce websites can be easily customised (and additional features can be derived), future studies may explore how the data can help address other challenges besides undervaluation.

Acknowledgement

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THE ENERGY AND EMISSIONS IMPACT OF CONTROLLED-ATMOSPHERE STORAGE AND DISTRIBUTION IN GLOBAL FRUIT SUPPLY CHAINS

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1. Introduction

The global challenge of climate change has become increasingly urgent in recent years due to the undeniable threat of greenhouse gas emissions (IPCC, 2022). Fortunately, consumers are increasingly making environmentally conscious decisions and are aware of their role and responsibility in mitigating and reducing the environmental impact of consuming products (Deloitte, 2022). Likewise, retailers are also stepping up to ensure a transition to sourcing more environmentally sustainable products (Chkanikova, 2016).

According to a recent study by Deloitte (2022), one of the significant barriers consumers and retailers face in making informed decisions regarding sustainability is access to helpful, accurate information. Surprisingly, almost half of consumers feel they do not have enough information to make informed choices of products when purchasing them (Deloitte, 2022).

One element neglected in current life cycle emission assessments of products is the emissions contribution of distributing goods in supply chains (Du Plessis, Van Eeden & Goedhals-Gerber, 2022a). Soon, consumers might want to understand the carbon emissions associated with each product or kilogram of produce they buy at a retail store. This interest is particularly true for food products such as fresh fruit due to the limited shelf life and seasonality thereof (Du Plessis et al., 2022a).

Accurately calculating the energy usage and carbon footprint of distributing products in complex global supply chains is, at best, challenging and time-consuming (McKinnon, 2018). This is particularly difficult for perishable products such as fresh fruit due to the large number of pre-carriage activities undertaken in the country of export, the variation in transport vehicles and equipment used in the country of export, the carbon intensity of energy sources, the duration of refrigerated storage, the variation between different shipments, and the origin-destination pairing, among other considerations. What is, however, certain is that fresh fruit distribution is particularly energy- and emission-intensive due to the limited shelf life and cold chain requirements (Du Plessis, 2023).

This paper aims to determine the energy usage and emissions of three types of fruit (oranges, table grapes, and apples) supply chains from South Africa to a retail supermarket in Edinburgh, Scotland. This is done to enable informed decision-making in sourcing fresh produce.

2. Literature Review

2.1. Carbon Labelling of Products

Carbon labelling refers to the practice of displaying greenhouse gas (GHG) related information about a product on its packaging (BSI, 2014). This information on the label typically includes the amount of GHGs emitted during the product's manufacturing, transportation, use and disposal phases, amongst other things. The Carbon Trust (2020) states that carbon labelling of products can help consumers make more informed decisions about the environmental impact of their purchases – thus, providing a new lever for environmentally conscience consumers to exert pressure on companies.

The concept of carbon labelling of products emerged after the Carbon Trust launched the world's first carbon labelling scheme in 2007 (Carbon Trust, 2023). Following the release, British retailer Tesco announced that it would carbon label all of its nearly seventy thousand products by 2012 (McKinnon, 2018). However, there were challenges to implementing a standardised carbon labelling system, such as calculating the carbon footprint of complex products and ensuring the accuracy of the information provided. Not only was the cost of this initiative exorbitant (£2 000 to £25 000 per product), but the time required to carbon footprint these products was also a limiting factor. After four years, Tesco's had only carbon

footprinted a mere 112 products or 0.16% of their product range (McKinnon, 2018). Other European retailers such as Casino, RAISIO and E.Leclerc also embarked on similar ambitious carbon footprinting projects, which were later abandoned due to feasibility and financial reasons (Taufique, Nielsen, Dietz, Shwom, Stern & Vandenberg, 2022).

Nevertheless, many retailers have implemented carbon labelling schemes, and many companies have voluntarily provided carbon labels on their products (Carbon Trust, 2023). Despite the significant challenges, the carbon labelling of products such as fresh fruit has the potential to play an essential role in promoting sustainable consumption and reducing GHG emissions of products.

2.2. The carbon footprint of controlled atmosphere storage and distribution of fruit

The carbon footprint of distribution in supply chains refers to the total amount of GHG emissions generated throughout the transportation and delivery of goods from the point of production to the retail store (Du Plessis, Van Eeden & Goedhals-Gerber, 2022b). It encompasses emissions from various activities such as road, rail, air, or deep-sea transportation and the handling and storage activities performed at logistical facilities such as cold stores, maritime ports, and distribution centres (DCs). Controlled atmosphere storage refers to the process of controlling the gaseous concentration and air temperature of fruit during storage. Pome fruit, such as apples and pears, are typically stored under controlled atmosphere for extended periods (up to 10 months) before packaging.

Various authors have investigated the proportional emissions contribution of distribution to fresh fruit's total life cycle emissions. However, according to the authors, no published peer-reviewed research explicitly focuses on the carbon footprint of long-term controlled atmosphere fruit storage. Although numerous authors such as (Svanes & Aronsson, 2013; Iriarte, Almeida & Villalobos, 2014; Roibás, Elbehri & Hospido, 2015; Boschiero, Zanotelli, Ciarapica, Fadanelli & Tagliavini, 2019; Bell & Horvath, 2020; Iriarte, Yáñez, Villalobos, Huenchuleo & Rebolledo-Leiva, 2021) assess the total life cycle emissions of fresh fruit, considerable research is still required to accurately reflect carbon emissions for various fruit supply chains.

3. Methodology

Due to the unique nature of this paper, a custom mixed-methods research methodology was used, as shown in Figure 1. This methodology is best suited since it uses various types of data – ultimately allowing for the triangulation of inputs and validation of results.

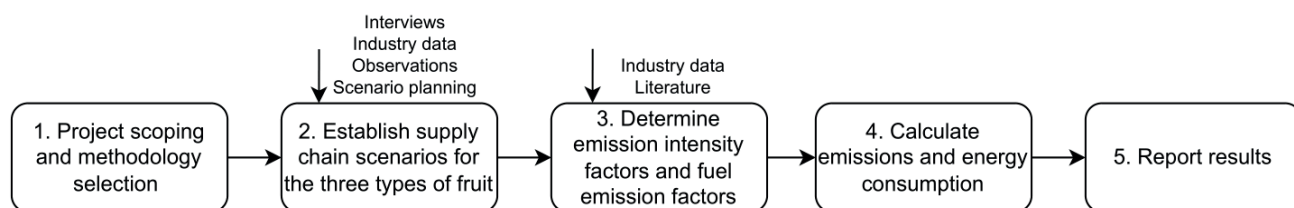


Figure 1: The research methodology used in this paper

3.1 Scoping and methodology selection

The first step of the paper, as shown in Figure 1, is to set the scope and choose a methodology for the assessment. This paper assesses the energy use and emissions from refrigeration and transport activities in the table grape and orange supply chains. As for apples, the paper assesses the long-term storage of the apples before packing and the refrigeration and transport from packing to the retail shelf. The paper, therefore, only assesses these fruit's cold storage and transport. In terms of the methodology used, this paper builds on the guidance of Du Plessis (2023), focusing on the South African fruit export industry. In addition, the Global Logistics Emissions Council (GLEC) Framework (Smart Freight Centre, 2019) was also used to inform methodology and emissions factors. Subsequently, the GHG emissions are calculated for the Well-to-Wheel (WTW) or total fuel life cycle emissions.

3.2. Supply chain scenario for each fruit

Three fruit supply chains originating from South Africa were explicitly chosen since the country is the largest exporter of fresh fruit by volume in the southern hemisphere (FPEF, 2022). The country is, therefore, a well-established source of fresh produce globally. South Africa was also the first southern hemisphere country to supply fresh fruit to the United Kingdom (UK) in 1892 (de Beer, Paterson & Olivier, 2003). Following these first successful shipments, the UK has become one of the major export markets for South African fresh produce.

Currently, the UK remains one of the top three markets for nearly all fruit types exported from South Africa (FPEF, 2022). Subsequently, three fruit types were chosen since they are popular and present in nearly every household pantry – oranges, table grapes, and apples.

Although various potential origin-destination pairs exist, a specific UK retail chains store in Edinburgh was chosen to align with the 2023 LRN conference location. Subsequently, the three fruit supply chains use specific distribution channels and facilities, such as the DC in Doncaster and the Port of Felixstowe. Therefore, all transport distances and storage durations in the three fruit supply chains have specific values.

The following step entails establishing and mapping the supply chain scenarios of each fruit. Several inputs, such as interviews with subject matter experts (SME), industry data collected from fruit exporters and AgriHub¹ data, observations at logistical facilities, and scenario planning, were used to explore and create different plausible supply chain scenarios. These supply chain scenarios are shown in Figure 2. Note that the transport distance or the storage duration at a logistical facility is indicated in bold in Figure 2. Further, note that the oranges and table grapes have “short” cold chains (less than 50 days from the tree-to-retail shelf), and the apples have a “long” cold chain (180 days or more from the tree-to-retail shelf).

¹AgriHub is an independent legal entity in the South African fruit export sector which collects, stores and provides industry data and statistics.

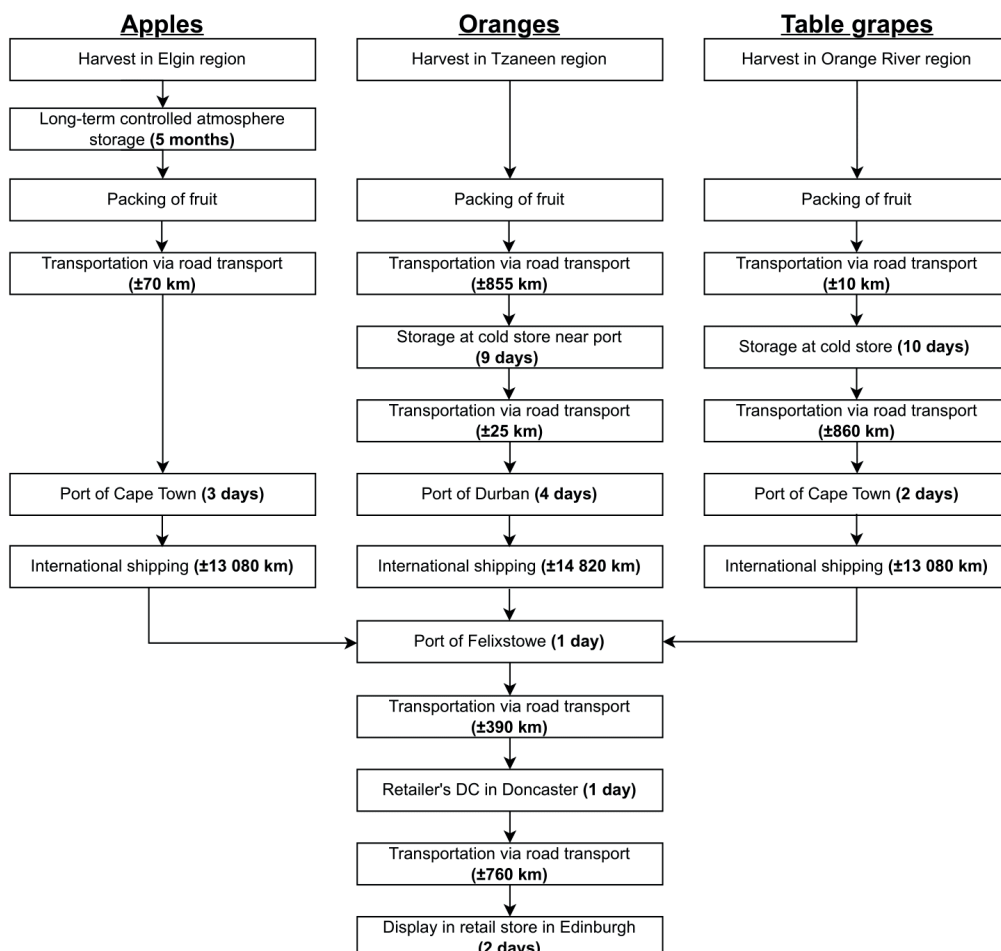


Figure 2: The supply chain scenario of each fruit type

3.3.Determine fuel and emission intensity factors

Determining and using valid and accurate fuel emission factors² and emission intensity factors³ are critical in the assessment. Regarding fuel emission factors, a grid emission factor of 0.97 kg CO₂e/kWh (Eskom, 2021) and 0.19 kg CO₂e/kWh (UK Government, 2022) was used for South African and UK electricity, respectively. In terms of the WTW emission factors for liquid fuels, a factor of 3.24 kg CO₂e/l was used for diesel, while 3.31 kg CO₂e/l was used for heavy fuel oil. No country-specific values are available to the authors. These fuel emission factors were used to convert emissions (kg CO₂e/kg fruit) to energy consumption (l fuel/kg fruit or kWh/kg fruit).

The emission intensity factors and units of analysis used to quantify emissions are stated in Table 1. The emission intensity factors from left to right in Table 1 indicate the supply chain activities in chronological order as they occur according to Figure 2. According to the authors' knowledge, these emission intensity factors are the most relevant and accurate representation of the real-world emissions associated with the proposed supply chain scenarios.

²A fuel emission factor is a numerical value that represents the amount of greenhouse gas emissions (CO₂e) released into the atmosphere per unit of fuel consumed.

³In this paper, an emission intensity factor is a numerical value which indicates the average amount of greenhouse gas emission (CO₂e) emitted when performing a supply chain activity.

Table 1: Emission intensity factors used to quantify emissions

	Pre-carriage					Main carriage	Post-carriage				Retail
	Controlled-atmosphere storage (kg CO ₂ e t-day ⁻¹)	Road transport (g CO ₂ e/t-km)	Cold storage (kg CO ₂ e pallet-day ⁻¹)	Road transport (g CO ₂ e/t-km)	Maritime container terminal (kg CO ₂ e/container, kg CO ₂ e day ⁻¹)	Container vessel (g CO ₂ e/TEU-km)	Maritime container terminal (kg CO ₂ e/container, kg CO ₂ e day ⁻¹)	Road transport (g CO ₂ e/t-km)	Storage and transport in DC (kg CO ₂ e/t)	Road transport (g CO ₂ e/t-km)	Retail display (kg CO ₂ e/m ² year)
Oranges	-	67	7.52	112	60.2, 175	276.2	60.2, 34.8	111.2	12.3	253.8	193.4
Table grapes	-	107	7.52	115							
Apples	10.8	115	-	-							

Source: (Tassou, Ge, Hadawey & Marriott, 2011; Dobers, Perotti & Fossa, 2022; UK Government, 2022; Du Plessis, 2023).

3.4. Calculate emission and fuel consumption

This paper calculates each activity's carbon footprint (kg CO₂e/kg fruit) according to Du Plessis (2023). To calculate the carbon footprint of all activities in the supply chain, Equation (1) was used:

$$\text{Carbon Footprint} = \frac{\sum \frac{\text{Emission Intensity Factor}_i \cdot \text{Logistical Data}_i}{\text{Nett Weight of Fruit}_i}}{(1 - \text{Losses} - \text{Wastage})} \quad (1)$$

Where: Carbon Footprint is the amount of CO₂e emissions (kg) emitted per kilogram (kg) of sold fruit, Emission Intensity Factor_i is the emission intensity factor from Table 1 for activity i, Logistical Data_i are variables specific to activity i such as weight, distance, storage duration, load factor of vehicle, percentage empty running, and the repositioning of container. Nett Weight of Fruit_i is the nett weight of fruit (kg) involved in activity i, Losses are the percentage (%) of fruit spoilt during the distribution process up to retail shelf, and Wastage is the percentage (%) of fruit fit for human consumption not sold. This paper uses 4% and 5% loss and wastage percentages, according to FAO (2011).

To calculate the energy consumption (l fuel/kg fruit or kWh/kg fruit) of the supply chains, the carbon footprint results from Equation (1) are grouped according to the type of fuel used in the logistical activity (i.e. electricity for logistical facilities, diesel for road transport and other mobile equipment, and heavy fuel oil for the maritime section) and divided by the fuel emission factors mentioned in Section 3.3.

The results of the three proposed scenarios included in this paper are reported next.

4. Results and Discussion

4.1 The carbon footprint of the three fruit supply chains

The carbon footprint (kg CO₂e/kg of fruit) of the orange, table grape, and apple supply chains is shown in Figure 3. According to calculations, the carbon footprint for oranges is 0.86 kg CO₂e/kg of fruit, 1.28 kg CO₂e/kg of table grapes, and 2.70 kg CO₂e/kg of apples. This means storing fruit such as apples for extended periods, maintaining the cold chain, and transporting the fruit between a packing facility in South Africa and a retail store in Edinburgh emits close to or more GHG emissions than the weight of the fruit distributed.

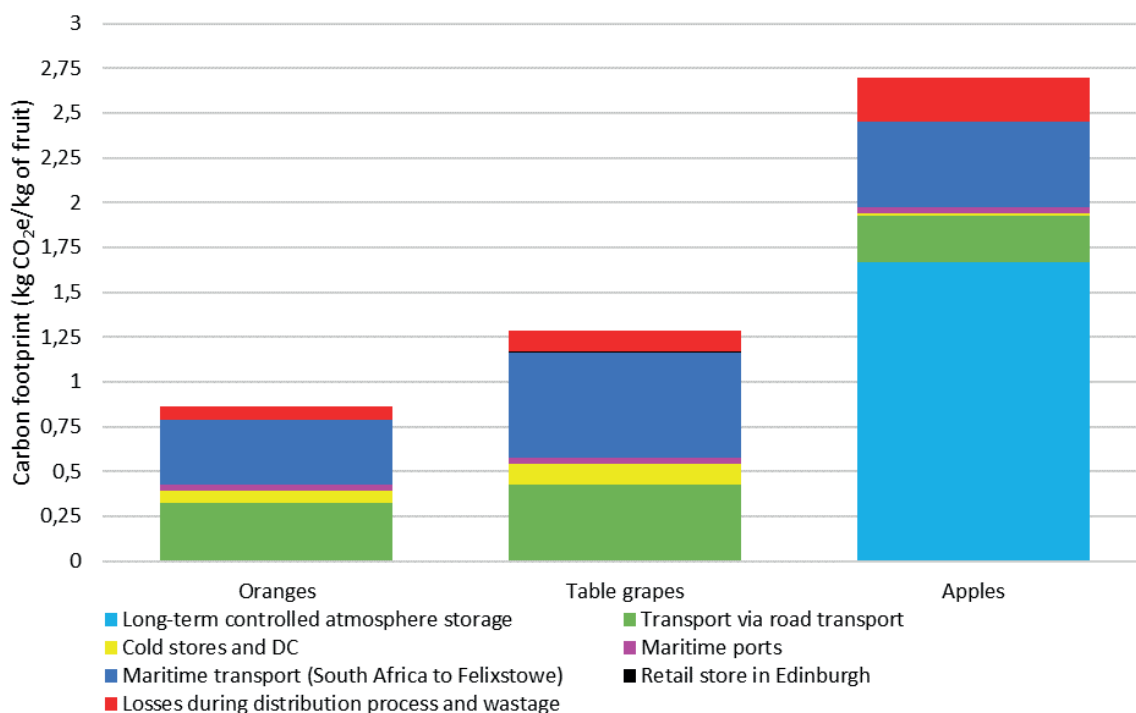


Figure 3: The carbon footprint comparison of the three fruit supply chains

Further, Figure 3 shows a noticeable difference between the carbon footprints of oranges and table grapes – even though both have a “short” cold chain (less than 50 days from the tree-to-retail shelf). This difference between oranges and table grapes is primarily due to the grapes being a “lightweight” fruit commodity. One high-cube pallet of table grapes weighs 30.6% less than a similar pallet of oranges. This results in each kilogram of grapes being responsible for “more” emissions.

The impact of long-term fruit storage also significantly influences the carbon footprint of the final produce. The “long” cold chain of apples (180 days from the tree-to-retail shelf) is primarily caused by the five-month controlled atmosphere storage of apples before packaging. The storage of the apples before packing contributes 61.8% to the total carbon footprint of 2.70 kg CO₂e/kg of apples. This iterates the potential impact that long-term cold storage activities can have on the emission intensity of perishable products.

Figure 3 also shows that maritime and road transport contributes between 41–45% and 33%–37%, respectively, of the total emissions of oranges and table grapes with “short” cold chains. Although not very significant, the contribution of other activities is still notable. Cold stores and the DC, maritime ports, and the retail store in Edinburgh collectively contribute 12.2% to the total carbon footprint of the “short” cold chains. The impact of food losses during distribution and retail wastage is also evident in Figure 3, which increases the carbon footprint of saleable fruit by a further 9%.

A detailed overview of all emission-generating activities between the packhouse and the retail shelf is also required to identify the proportional contribution of pre-, main-, and post-carriage activities. Figure 4 indicates the proportional contribution to the total carbon footprint of the table grapes. From Figure 4, it is evident that pre- and post-carriage activities, losses, and wastage in the specific table grape supply chain contributed 54% to the total carbon footprint. The maritime leg, however, remains the single most significant emissions contributor to the carbon footprint of the grapes. Also, note that the last-mile road transport between the retailer’s DC and retail store is responsible for 19% of the total product carbon footprint.

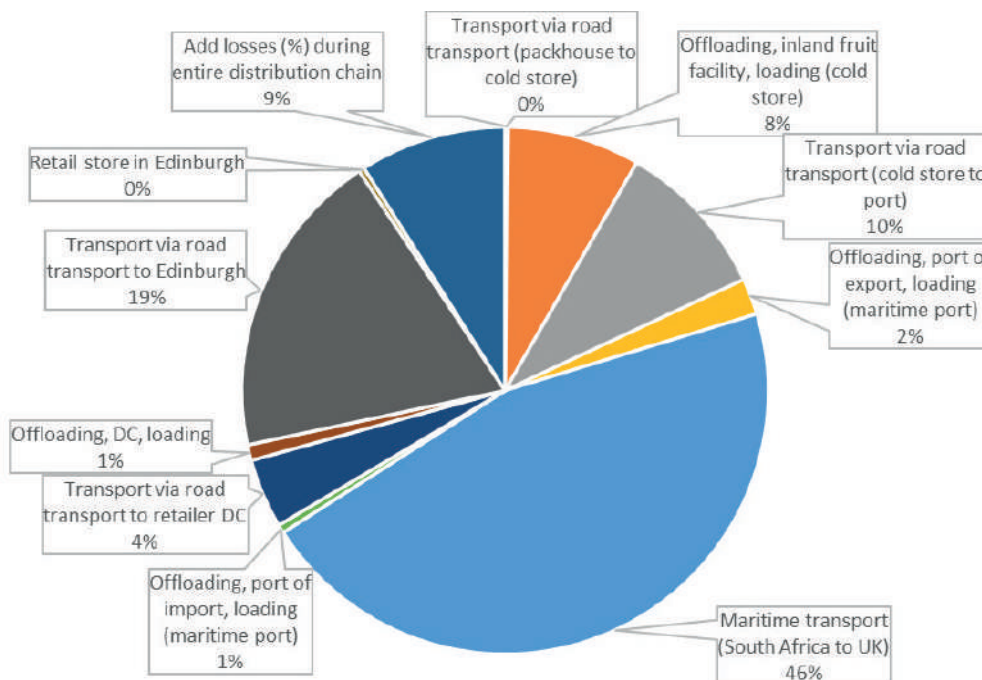


Figure 4: Overview of the carbon footprint of table grapes from a packhouse in South Africa to a retail shelf in Edinburgh

4.2 The energy consumption of each fruit’s supply chain

Results show that energy consumption (diesel, heavy fuel oil, and electricity) varies considerably for different fruit types, as shown in **Table 2**. The energy consumption for “short” cold chains such as the oranges and table grapes varies between 0.10–0.13 l of diesel/kg fruit, 0.11–0.18 l of heavy fuel oil/kg fruit, and between 0.15–0.22 kWh/kg of fruit. “Long” cold chains (fruit such as apples with a cold chain of 180 days) use approximately 8–12 times more electricity than the “short” cold chains. This iterates the energy intensity of storing fruit for long durations compared to other distribution activities. Apple supply chains, however, exhibit similar diesel and heavy fuel oil consumption compared to the two fruit types in **Table 2**.

Table 2: The energy consumption of the different fruit

	Diesel (ℓ/kg fruit)	Heavy fuel oil (ℓ/kg fruit)	Electricity (kWh/kg fruit)
Oranges	0.10	0.11	0.15
Table grapes	0.13	0.18	0.22
Apples	0.08	0.14	1.81

5. Conclusion

In conclusion, this study provides a comprehensive assessment of the energy use and emissions associated with three different fruit supply chains from South Africa to a retail supermarket in Edinburgh, Scotland. The results highlight the significant impact of cold chain duration and the potential energy and GHG emissions impact of long-term controlled atmosphere storage of fruit. The study also identifies the most energy- and emission-intensive distribution activities, providing valuable insights for stakeholders to evaluate and improve the sustainability of fruit supply chains. This study contributes to the body of knowledge on sustainable food systems. It provides important information for policymakers, researchers, and consumers to make informed decisions about the environmental impact of their food choices. Overall, this research underscores the importance of reducing energy consumption and emissions associated with fruit supply chains to achieve a more sustainable food system.

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UNDERSTANDING THE VIABILITY OF DRONE LOGISTICS FOR ASSISTING PATHOLOGY TRANSPORTATION: A CASE STUDY IN DORSET, UK

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Introduction

There is a growing interest in Uncrewed Aerial Vehicles (UAVs, hereinafter referred to as drones) being used in medical logistics, including within the UK's National Health Service (NHS). A number of trials have already taken place within the UK and abroad to test the capabilities of drones within healthcare. Following trials in developing countries, Zipline have successfully launched commercial operations in Rwanda, transporting blood and other medical supplies (Ackerman & Koziol, 2019).

Within the UK, projects are trialling the use of drones in delivering medical supplies between hospitals and medical practices (Sargeant, 2022). The NHS are interested in the various benefits that introducing drones into their transport fleets could have on both CO₂ emissions and patient care. This paper assesses the impact that drones could have on current van-based pathology logistics. The business-as-usual (BAU) land-based pathology logistics for 3 hospitals and their associated GP surgeries in Dorset (UK) were modelled using historic sample collection data. Subsequently, a theoretical fleet of drones have been chosen to allow for the modelling of a new pathology logistics system with drones integrated alongside vans. This paper compares the financial costs, CO₂ emissions and patient care implications of introducing drones into an integrated mixed-mode pathology logistics model.

The aim of the paper was to determine the viability of using drones to collect, transport and deliver medical samples from rural GP surgeries, as part of the existing van-based logistics system and quantify to what extent the overall transport footprint in terms of environmental impacts can be reduced whilst minimising in-transit time of samples travelling to the pathology labs.

Literature Review

Pathology is the study of diseases, predominantly through diagnostic testing of patient samples (The Royal College of Pathologists, 2023b). 80% of treatment plans are created after some sort of pathology testing (Guy's and St Thomas' NSFT, 2019), therefore reducing the result turnaround time would improve patient care. The target time between collection and delivery of diagnostic samples is often around 4 hours.

The NHS have developed a plan to reach net zero carbon emissions by 2040. This means that a considerable reduction in emissions is required. Transport produces 14% of the NHS' CO₂, therefore, the 90% of the fleet will be low, ultra-low and zero-emission vehicles by 2028 (NHS, 2020). Drones present an alternative logistics system which have been successfully trialled in both the UK and abroad. However, this technology is currently limited by CAA regulations. The CAA place any drones carrying dangerous goods in the Certified category, meaning that all flights must be authorised by the CAA. Additional limitations are imposed on any drones carrying dangerous goods, including the requirement of closed airspace around the drone (Civil Aviation Authority (CAA), 2020). Diagnostic specimens are classified as UN3373 (International Civil Aviation Organization (ICAO), 2011), therefore any drone carrying them must have specific permissions from the CAA (Civil Aviation Authority (CAA) & UK Research and Innovation, 2021).

To meet the dangerous goods requirements, pathology samples are currently carried in Versapak Insulated Pathology Transport Carriers (hereafter Versapaks). Any drone collecting specimens would need to be able to carry either a small or medium Versapak (Table 1) (Versapak, 2015).

External Dimensions (mm)	Estimated Full Weight (kg)	Estimated Sample Capacity
305 x 305 x 170	2.5	20
460 x 305 x 255	5	50

Table 1: Versapak Sizes (Versapak, 2015)

Methodology

The objectives of this study were met by carrying out a desktop analysis of historic data in the south Dorset region of the UK. Building on existing literature, the current pathology routes were analysed using RouteXL and Routific in order to geospatially audit sites and optimise vehicle routes. Data were provided by the relevant NHS trusts via the EPSRC E-Drone project (www.e-drone.org), and contained details of existing vehicle rounds, such as collection and delivery times, and typical sample production rates by each site.

The base data showed which GP surgeries were serviced by each round. The dataset gave the collection and delivery times for each surgery, however there was no indication of the exact route the vans used for each round. There was also no information about what other collections or deliveries the vans may have been undertaking on their rounds. Therefore, a best guess of the routes was taken using RouteXL to find the shortest path.

An intervention scenario using a combination of vans and drones was proposed, with sites being identified for drone service using vehicle travel times. Sites were selected if they were more than 20 minutes driving time from the delivery hospital and had a minimum of 100 m² of available landing space (Oakey et al., 2022a). The chosen surgeries were removed from the business-as-usual van routes and the new van and drone routes were analysed. This led to a comparison between the business-as-usual and drone model cost, CO₂ emissions and transit time.

It was determined that a fleet of drones consisting of various configurations would be the most effective way to service the outlying surgeries. The drones needed to be able to withstand 14 m/s wind gusts and 50 mm/h precipitation (Oakey et al., 2022a). They must be able to carry a small or medium Versapak and have a minimum range of 25 km. The proposed fleet was made up of the AirLogiX Hammerhead ev20 and the Wingcopter 198.

The AirLogiX Hammerhead ev20 is a fully electric tilt-rotor drone. This allows it to take-off and land vertically, minimising the runway space needed at the GP surgeries. The drone can carry either a small or medium Versapak (AirLogiX, 2022). The Wingcopter 198 (Wingcopter, 2023) uses a cable system to deliver packages without having to land. This would make the collection of pathology samples easier by removing the need for landing space and allowing the delivery route to be one single automated trip. The drone is a tilt-rotor which allows it to hover over the delivery location, but fly long distances in a fixed-wing configuration which is more efficient. Table 3 gives the specifications for both drones.

Drone	AirLogiX Hammerhead ev20	Wingcopter 198
Payload	20 kg	5 kg
Range	100 km	65 km
Wingspan	4.7 m	1.98 m
Cargo bay size	884 x 396 x 274 mm	400 x 650 x 220 mm
Cruise Speed	72 km/h	100 km/h
Max. Flight Time	60 mins	35 mins
Wind Resistance	25 m/s (30 m/s gusts)	15 m/s (20 m/s gusts)
Versapak Size	Medium	Small

Table 3: Drone specifications (AirLogiX, 2022) (Wingcopter, 2023)

Results and Discussion

Business-as-Usual Analysis

Analysis of the current logistics system was critical to support understanding of if, where and how drones could be used to support a future pathology transportation network. To assess the current situation, Dorset GP surgeries were used as a case-study. Three hospitals with sample analysis laboratories featured in the case study area: Royal Bournemouth Hospital (BCH), Dorset County Hospital (DCH) and Poole Hospital in Dorset; together serving a total of 72 GP surgeries and clinics (Figure 1). Samples are collected on set routes by vans at pre-agreed times. As of 2020, there were currently 9 collection routes per day, with some variations to routes between days.



Figure 1: Dorset GP surgery locations

To better understand the geographical arrangement of the Dorset case-study, all current pathology collection routes were plotted using RouteXL (www.routexl.co.uk/). The majority of surgeries only were only served by 1 collection per day, though 9 surgeries received 2 collections per day, and 6 surgeries received 3 collections a day.

The dataset gave the collection and delivery times for each surgery, though in the absence of specific routing details, RouteXL was used to identify the shortest path. Additionally, no information was given regarding about what other collection or delivery services the vans may have been undertaking on their rounds. Table 2 presents the results from the route mapping.

To provide a business-as-usual baseline that was more representative of just the patient sample collections, Routific (<https://routific.com/>) was used to reoptimise the pathology collection routes. These routes (Table 3) were subsequently used as the business-as-usual comparator in results.

Each of the 3 hospitals has a group of GP surgeries which it runs collections for. Therefore, their routes were optimised independently of each other to ensure the correct samples were delivered to each laboratory. The data for the GP surgeries serviced by the relevant hospital were input with an estimated number of delivery vans. Routific optimised each scenario for the minimum overall service time and distance, therefore, minimising the number of collection rounds. Table 3 outlines the optimisation results.

Route	Hospital	No. of Stops	Route Time (hr:min)	Distance (km)	CO ₂ Emissions (kg)
Blue Run	Poole Hospital	8	04:10	76.9	21.5
Green Run	Poole Hospital	11	06:10	71.2	19.9
Red Run	BCH	8	04:10	38.1	10.7
White Run	BCH	13	06:01	60	16.8
Yellow Run	Poole	11	05:36	39.4	11.0
Dorchester Run	DCH	14	06:18	142	39.7
South West Run	DCH	2	02:17	100	28.0
Ad-hoc & Weymouth Run	DCH	16	03:41	78.2	21.9
North Dorset (Mon, Thurs) Run	DCH	10	06:22	168	47.0
North Dorset (Tues, Fri) Run	DCH	11	05:52	169	47.3
North Dorset (Wed) Run	DCH	8	04:52	151	42.2

Table 2 – Current Dorset pathology collection route data

Hospital	No. of vans	No. of stops	Total Time (hr:min)	Total distance (km)	CO ₂ Emissions (Kg)
DCH	3	26	10:06	293.0	81.9
Poole Hospital	5	25	08:06	191.4	53.3
BCH	2	21	04:30	63.7	17.8

Table 3: Business-as-usual Routific results for DCH, Poole Hospital and BCH

Selection and Allocation of Drone Served GP Surgeries

Drones can be integrated into the existing collection routes with the aim to further optimise time, distance and CO₂ emissions. To do this effectively, appropriate GP surgeries and drones were selected.

Figure 2 shows travel time isochrones for 20 minutes driving from each of the three hospitals, with the surgeries that fell outside of these catchments clearly identified. It was apparent from this analysis that the GP surgeries serviced by the Royal Bournemouth Hospital are fell within the 20-minute catchment area, therefore, there would be little benefit from integrating drones into the hospital's pathology logistics network.

In contrast, 13 of outlying surgeries from both Poole Hospital and Dorset County Hospital were identified. These locations were subsequently selected for drone service to reduce the time, distance and environmental impact of the current routes.

To meet the daily sample production rates of each of the drone-served sites, different carrying capacities would be required. Furthermore, the round-trip distances and landing space restrictions limit the suitability of different drones for each site.

To this end, the payload characteristics, round trip distance, and landing space were used to allocate a given number of each drone to each of the drone-served sites. Table 4 shows the drone allocations.

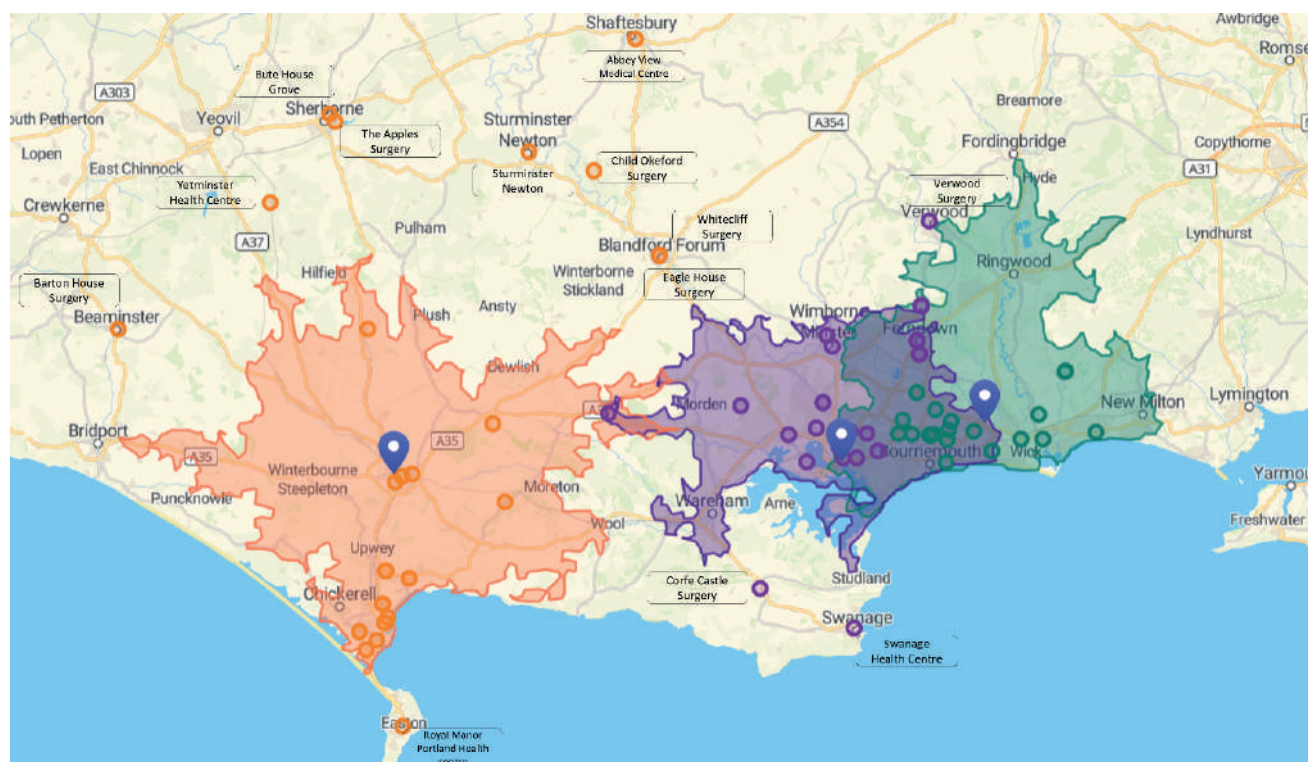


Figure 2: 20-minute driving travel time isochrones showing from each hospital (pins), with surgeries indicated by circles. Colours indicate the associated hospital (orange = Dorchester, purple = Poole, green = Bournemouth)

GP Surgery	Hammerhead	Wingcopter
Abbey View Medical Centre	2	
Barton House Surgery		2
Bute House Grove Medical Centre	1	
Child Okeford Surgery	2	
Corfe Castle Surgery		1
Eagle House Surger	2	
Royal Manor Portland Medical Centre	1	1
Sturminster Newton Medical Centre	1	1
Swanage Health Centre	1	1
The Apples Surgery	1	
Verwood Surgery	1	
Whitecliff Surgery	2	
Yetminster Health Centre		1
Total Flights	14	7

Table 4: Drone allocations for each GP surgery

Re-Optimisation of Van Routes

With drone services eliminating the need for vans at many surgeries, re-optimised van routes were produced using Routific, excluding the drone sites from service requirements (Table 5). As seen in Table 6, a 50% reduction in the tailpipe emissions of the system resulted from the introduction of 21 drone flights by 5 drones in place of 4 vans routes. It should

be highlighted that these results compare diesel fuelled vans with electric drones with no tailpipe emissions; however, in practice the emissions requirements of drone services may not necessarily offer whole lifecycle emissions reductions when the generation of electricity is considered and potential changes to electric vans are considered (Oakey, 2023).

When comparing costs (Table 7), the drone-based intervention increases operating costs by 58% over the business-as-usual case. The reduction in the number of vans and distance travelled offsets the introduction of drones to some extent, though the additional costs of using drones presents a potentially unsustainable financial burden.

In return for the additional costs, transit time to the drone served surgeries are reduced by an average of 83% (Figure 3). Those surgeries which faced a significant volume of stem mileage in the business-as-usual case benefitted most, with more direct drone routing offering the greatest decreases in transit time. Nonetheless, it should be noted that future drone routes may not necessarily follow the most direct path due to constraints around airspace and ground risk (Oakey et al., 2022b).

Hospital	No. of vans	No. of stops	Total Time (hr:min)	Total distance (Km)	Tailpipe CO2 Emissions (Kg)
DCH	2	16	04:31	103.5	28.9
Poole Hospital	2	22	05:11	102.0	28.5
BCH	2	21	04:30	63.7	17.8

Table 5: Routific results for DCH, Poole Hospital and BCH with GPs serviced by drones removed

Hospital	BAU CO2 Emissions (kg)	Drone Model CO2 Emissions (kg)
BCH	17.8	17.8
DCH	81.9	29.6
Poole	53.5	28.9
Total	153.3	76.3

Table 6: Tailpipe CO2 Emissions for each hospital for the business-as-usual and drone models for 1 days' rounds

Hospital	BAU Cost (£)	Drone Model Cost (£)
BCH	£66.11	£66.11
DCH	£192.42	£361.85
Poole	£141.41	£203.17
Total	£399.94	£631.13

Table 7: Costs for each hospital for the business-as-usual and drone models for 1 day's rounds

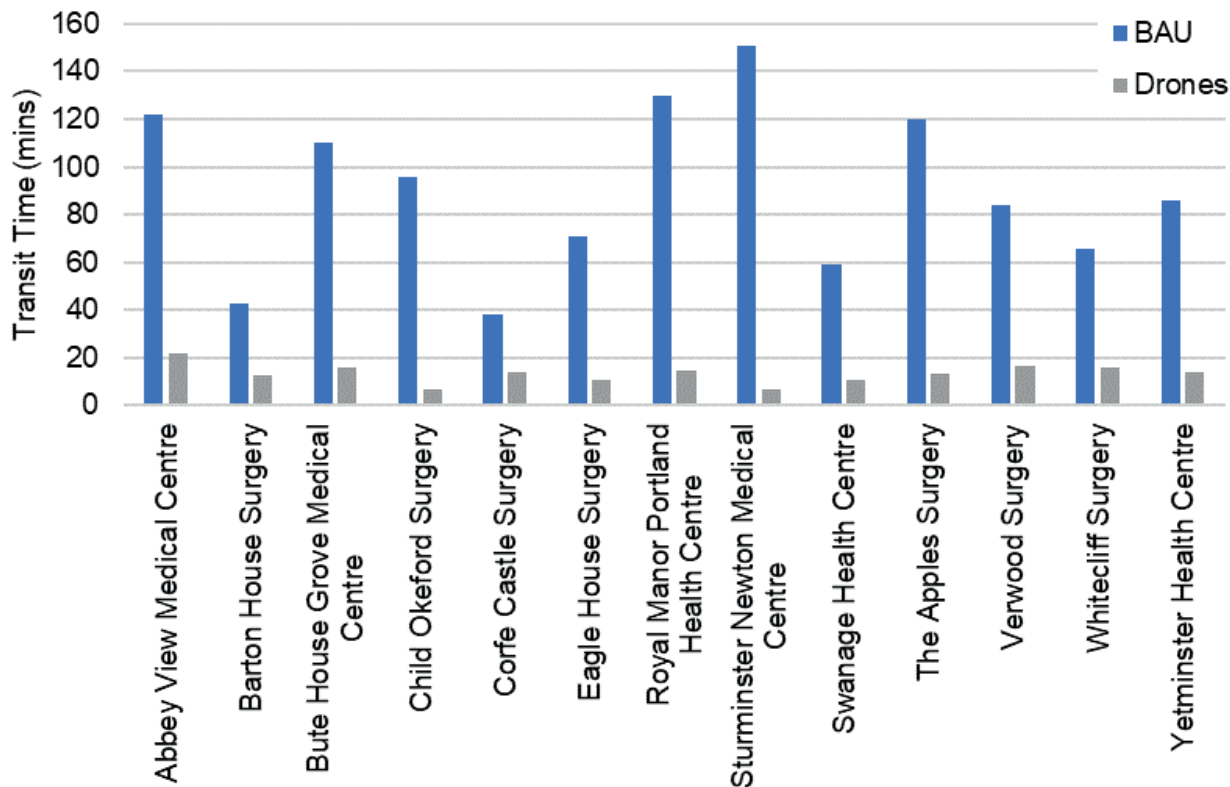


Figure 3: Comparison of BAU and drone delivery times for drone serviced GP surgeries

Conclusions

In the optimised BAU situation, 10 vans were used to service 72 surgeries generating 548.1 km, 153 kg CO₂ and taking 22.7 hours of transit time at a cost of £399.94 per day. The introduction of 5 drones serving 13 remote surgeries and picking up 678 samples (14% of the daily total) would remove 4 vans and decrease the overall daily emissions by 77 kg of CO₂ (50% under current BAU).

These overall system benefits would come at an additional cost of £231.19 per day (58% over current BAU) due to the significant costs associated with drone service. Although the cost is a substantial consideration in the viability of drone logistics, it is also important to consider the impact it would have on patient care. The 13 GP surgeries serviced by the drones would have a decreased sample delivery time of 83% on average over BAU. This could positively impact on bleed-to-diagnosis times and is an important consideration for the NHS, who are working towards improving patient experience and reducing overall treatment times; however, the true impact of decreased transit time remains uncertain.

Limitations

The cost calculations used for modelling the introduction of drones do not take into account any one-off start up costs such as reception facilities or regulatory fees, they only represent day-to-day running costs. Further research would be needed to provide a more accurate financial estimation.

The drones were also assumed to fly as-the-crow-flies. In reality, this would not be possible due to airspace restrictions, particularly around Bournemouth Airport. Additional modelling would be required to plot the exact routes the drones would need to take to avoid any restrictions, adding to the transit time, distance and CO₂ emissions of the drones.

Other regulatory barriers have also been ignored, given they would currently prohibit regular drone operations. There would need to be changes to the Civil Aviation Authority (CAA) guidelines for this drone model to be introduced.

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MAKING THE CASE FOR DESIGNING A SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEM INCORPORATING RESILIENCE AND SUSTAINABILITY

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Introduction

This research looks at understanding how current supply chain performance measurement systems (SCPMS) are capturing resilience and sustainability measures.

Resilience and sustainability are two distinct but interconnected characteristics of a supply chain in any industry. The current supply chain performance measurement systems (SCPMS) predominantly consider economic and environmental measures (Rajeev et al., 2017). The resilient paradigm focuses on the supply chain's capability to absorb, prevent, and recover from disruptions, while the sustainability paradigm looks at economic, environmental, and social impact. Many academic papers (Xu, Marinova and Guo, 2015; Sarkis, 2020; Rajesh, 2021; Yaghoubizadeh Vanini et al., 2022) recognised and acknowledged the interconnection and overlap between these two paradigms; however, the consideration of both paradigms in conjunction within the SCPMSs (Supply Chain Performance Measurement Systems) is limited within the performance measures identified (Fahimnia, Jabbarzadeh and Sarkis, 2015; Ivanov, 2018). Also, the interaction and overlap between measures of resilience and sustainability in SCPMSs are widely argued (Beske-Janssen, Johnson and Schaltegger, 2015; Fahimnia, Jabbarzadeh and Sarkis, 2015, 2018; López and Ruiz-Benítez, 2020) in the literature. Therefore, a question arose, what are the measures for supply chain sustainability and resilience captured in current performance measurement systems? A systematic literature review (SLR) was performed to answer this question.

In the next section the SLR methodology is presented and followed by the findings and discussions from the included papers. The conclusion appears in the closing section.

Methodology

This section describes the steps that were followed in the research process in detail and their execution. The steps explained here are based on Denyer and Tranfield (2009).

Scoping study

An initial search was considered in the area of supply chain performance measures of resilience and sustainability. This was done using the databases of SCOPUS and Web of Science using the keywords "supply chain," "performance measurement," "resilience" and "sustainability." The search results were then restricted to reviews only to identify any systematic literature reviews (SLR). This resulted in no relevant documents. Hence this showed that there are no SLRs (Systematic Literature Review) that specifically look at supply chain performance measurement systems that incorporate resilience and sustainability.

Comprehensive search strategy

Based on the scoping study, the following keywords were decided on for the SLR.

Supply chain; supply chain performance*; performance measure*; performance metric*; index; key performance indicator* (KPI); resilience; sustainab*.*

Using Boolean operators of AND and OR, the search string for the searching within Scopus and Web of Science as follows-

"supply chain" AND ("performance" AND ("indicator" OR "measure" OR "metric" OR "key performance indicator*")) AND ("resilience" AND "sustainab*")*

Literature Search and Inclusion Results

The above keywords were used for searching in Scopus database on 15th May 2023. It returned 48 documents. The time-period for the results available were 1998 to 2023. The search results were further filtered to only include peer-reviewed articles. Within these articles, only those were included which were written in English.

Similarly, the keywords search on WoS returned 78 documents. After filtering for peer-reviewed articles published in English only, gave a final document list of 68.

Exporting data and duplicate deletion

The selected documents were exported in the Excel format from Scopus and Web of Science. These were then combined into a single document for ease in the screening that is to be followed in the next step.

The new combined Excel sheet will contain duplicates, since both databases list many of the same journal papers. These duplicates were identified and removed. The final number of articles that was present after the duplicates were removed was 81.

Title, abstract and keywords screening

In this stage, the title, keywords, and abstract were screened to ensure suitability to the research. The keywords from the search strategy were also used to exclude certain articles.

Table 1. Overview of Inclusion/exclusion criteria

E/I	Criteria	Criteria Explanation
Exclusion	Language (L)	A paper in other languages aside English
	Non-journal articles	To ensure quality and consistency in the analysis, all articles which were not peer-reviewed were excluded. Books, book chapter, review articles and conference papers were excluded (Beske-Janssen, Johnson and Schaltegger, 2015).
Inclusion	Articles in English	Most academic journals are published in English
	Related papers	Articles that address the main area of enquiry of supply chain performance measurement systems that look at both sustainability and resilience.

Upon careful screening of the abstract, title and keywords based on the inclusion/exclusion criteria listed above, the researchers were left with 25 articles for full text reading and review.

Explicit selection criteria

Using the inclusion and exclusion criteria from Table 1, the articles were thoroughly evaluated through reading. This resulted in a further 8 articles being excluded.

The reading also included a snowballing effort where the citations and references within these articles were assessed for their suitability to the study. This resulted in the inclusion of 5 articles to the study. Therefore 22 articles were included for further analysis, which are listed in the reference section (see Figure 1).

Evaluation

Since the articles were restricted to peer-reviewed articles from journals only, this step did not result in the exclusion of any more articles.

Extraction and Synthesis

An interpretative approach is used to thematically analyse the articles to synthesise findings from the included literature. The software package NVivo was used for this step. Within the included papers, this study identified what are the measures that were used to measure sustainability and resilience. These were coded into NVivo, using which the overlaps between various measures were identified. These are described in the Findings and Discussion section below.

Reporting

Based on the findings from the thematic analysis, conclusions are drawn on what is found in literature, while also emphasising what is not found thus illuminating the gap in the literature. This is described in the Findings and Discussion section.

Utilisation

How the findings and the discussion based on this analysis can be utilised to further research in their area it is approached in the conclusion section.

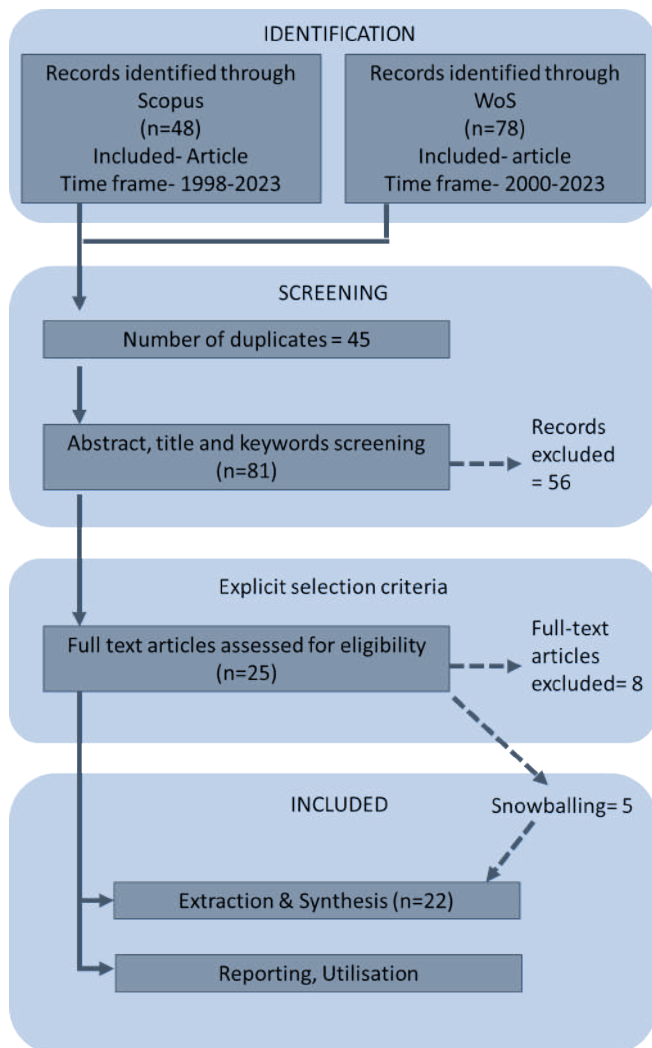


Figure 1. Overview of the included studies

Findings and Discussion

The analysis of the papers included in this study revealed that a few performance measures overlapped between the category of resilience and sustainability. For example, Flexibility is described by Azevedo et al., (2013), Mohammed et al. (2018), Sen, Datta and Mahapatra (2018), Alimohammadlou and Khoshsepehr (2022), Attia et al. (2023), Patidar et al. (2023), Torres Vergara, Saucedo Martínez and Olivo Lucio (2023), Vergara, Martínez and Salais-Fierro (2023) as a measure of resilience where it allows for quick changes of operations in their supply chain to ensure that continuous supply of material is available during a disruptive event. Also, Azadi, Moghaddas and Farzipoor Saen (2022) described it within the economic measure of sustainability, where it signifies the ability of an organisation to easily scale to meet the demands of the consumer.

Similarly, Kayikci, (2020), Alimohammadlou and Khoshsepehr (2022), Attia et al. (2023), Patidar et al. (2023), Torres Vergara, Saucedo Martínez and Olivo Lucio (2023) and Vergara, Martínez and Salais-Fierro (2023) defined collaboration as a measure of resilience from the perspective of partnerships that enable the organisations to achieve mutually beneficial results. Azevedo et al. (2013) also described collaborative planning with customers as measure of resilience where the collaboration brings mutual benefit to both the organisation and the customer, while also making the organisation sensitive to any changes in demand. However, Azevedo et al. (2013) and Sen, Datta and Mahapatra (2018) described environmental collaboration with supplier and environmental collaboration with customers as an environmental measure of sustainability, where collaboration is used as tool to improve the capability of the organisation to develop green products.

Sen, Datta and Mahapatra (2018) defined co-ordination with downstream partners as a measure of resilience where there is exchange of information on inventories and demand conditions from downstream members to be able to be more sensitive to demand and supply changes.

Attia et al. (2023) described transparency as a key measure of resilience, while Torres Vergara, Saucedo Martínez and Olivo Lucio (2023) described transparency from the perspective of social measure of sustainability, as a part of collaborative win-win based on co-operation between the members.

Despite the compelling arguments for the intersection between resilience and sustainability within the context of supply chain performance measurement, there is limited overlap among the various performance measures within the included studies. The only performance measures discovered that are overlapping between the category of resilience and sustainability are flexibility, collaboration, and transparency measures. Amongst these, collaboration is the only measure that was identified as overlapping within the same study (Azevedo et al., 2013). This study indicates the interrelationships and interactions between these measures are yet to be studied thoroughly and the representations of these two concepts in SCPMSs can be inchoate and ambiguous.

Conclusion

The sustainability paradigm looks at environmental, economic, and social impact while not considering the effect these disturbances have on the system. Similarly, the resilient paradigm focuses on the supply chain's capability to absorb, prevent, and recover from disruptions while not considering the environmental impact of mitigation and contingency strategies (Azevedo et al., 2013).

There are sufficient examples of SCPMS that capture the importance of both sustainability and resilience measures. However, there is still a need to enhance understanding of the performance measures that brings an overlap between resilience and sustainability. These performance measures then need to be concurrently incorporated into a SCPMS which will help operations managers to better understand the interrelationships and interactions between them. This understanding will bring to light the various trade-offs and synergies that exist between resilience and sustainability. This is necessary to measure and improve the total performance of the supply chain by managing disruption risks while also minimising environmental risks.

As further work, this study is looking to (1) Investigate the trade-offs and synergies between the various supply chain measures through modelling and simulation, (2) investigate the effect of overlapping in the SCPMSs, (3) to include a more comprehensive bibliometric analysis, and further emphasise the overlaps between the measures of resilience and sustainability.

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RECONFIGURING FOOD SUPPLY CHAINS USING ALTERNATIVE PROTEIN SOURCES

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Background, Introduction and Approach

Supermarkets around the world offer an ever expanding range of vegetarian or vegan products, using packaging, labelling and advertising to highlight their 'green credentials', accompanied by government-led campaigns in social media and other outlets. However, measuring greenness is far from easy, owing to the complexity inherent in the global food system (Accorsi and Manzini 2019; Dani, 2019; Rogers and Dora, 2022; Rust et al, 2020). An example from a plant-based burger sold in the USA gives some insights into this complex situation; the main ingredient (peas) is grown in the USA and rice- a smaller but important ingredient for the blend- is imported from India and China. Both crops are harvested and shipped to China, where they are processed into individual components. The extracted protein is shipped back to the USA in containers to the US border, then by train to Colorado where it is processed further. It is turned into a patty and packaged, and sent to distribution centres around the US under cold chain conditions by refrigerated trucks. Finally, it is taken by road to a specific retail store prior to being sold to the end consumer (Zimberoff, 2021). This is by no means a one-off and similar examples occur in many other products (food or otherwise). This 'simple' example indicates that the supply chains associated with these alternative protein products may not always be straightforward to understand, in terms of their overall sustainability in comparison to equivalent animal protein-based products. The label may say 'made in the UK', but this can mask many thousands of miles hidden within the processing steps of the final product. This leads us to consider that eating locally-sourced, meat may in fact have a smaller overall environmental impact. Similarly, from the social indicator perspective labour is a critical issue. Producing traditional meat is highly labour-intensive. Meat supply chains include majority small- and medium sized farmers and economically vulnerable labourers. A transition towards a more plant-based meat needs serious planning and in depth understanding, as well as a cohesive strategy for better labour engagement.

The so-called 'alternative protein' products market is experiencing robust growth, both within Europe and further afield. This is in some ways a broad categorisation that has come to represent all non-meat alternatives. One definition by the good food institute considers alternative proteins to encompass protein based foods produced from plants, from cultivated animal cells or by way of fermentation (Good Food Institute, 2022). As part of a large EU project, the Smart Protein Team demonstrated a clear trend towards sustainable, ethical and overall healthier foods. In a large scale survey in 2021, they found that 40% of European consumers intend to consume less meat and more plant-based or hybrid products (The Future of Protein Production, 2022). A major driver for this change is that long term consumption of meat with a high fat content has been linked to serious health conditions (Fortune Business Insights, 2022).

Within the alternative protein sector, a notable growth area is pea protein-based products, manufactured using textured protein extracted from green and yellow peas. Pea protein has a low environmental footprint, needing significantly less water during the production process compared to meat-based products (USDA, 2021). As pea protein is relatively low cost, non-GMO and largely non-allergic, the market potential is clear (Legume Perspectives, 2022). In fact, until 2028 the market is estimated to grow at a CAGR of 12%, representing a market size of 1,026 million USD (Fortune Business Insights, 2022).

Following on from earlier work that focused on understanding the market for alternative proteins (Rogers and Srivastava, 2021; Rogers and Dora 2022), this research focuses instead more specifically on identifying and evaluating existing sustainability KPIs for pea protein-based products. It then uses these findings to map the main elements of pea protein-based product supply chains. The research is rounded off by reflecting on to what changes need to take place across and along these supply chains. Future research will then take a closer look to determine to what extent food supply chains need to be reconfigured to adapt to increased customer demand in this thriving sector.

Indicative KPIs – The FAIRR-GFI Alternative Proteins Framework

As an example of an existing industry-focused measurement system, we took the FAIRR-GFI Alternative Proteins Framework which is a reporting tool designed to be used by alternative protein manufacturers and suppliers. This was developed together with investors, innovators and NGOs within the alternative proteins food sector to standardize reporting in the industry. It also serves to collate Environmental, Social and Governance (ESG) opportunities and risks from the perspective of alternative protein manufacturers and suppliers. It is accessible for all via a downloadable dynamic Excel sheet (FAIRR, 2022). The framework structure beyond the three main ESG pillars, including the main themes and sub themes is shown in Figure 1. The fact that it is comprehensive, with over 100 questions to be answered by the stakeholders, poses a potential barrier in that the time and effort to complete these questions in a meaningful way is extensive. Furthermore, unlike other ESG-related activities, there is currently no legal requirement to complete it, which clearly reduces the motivation to do so.

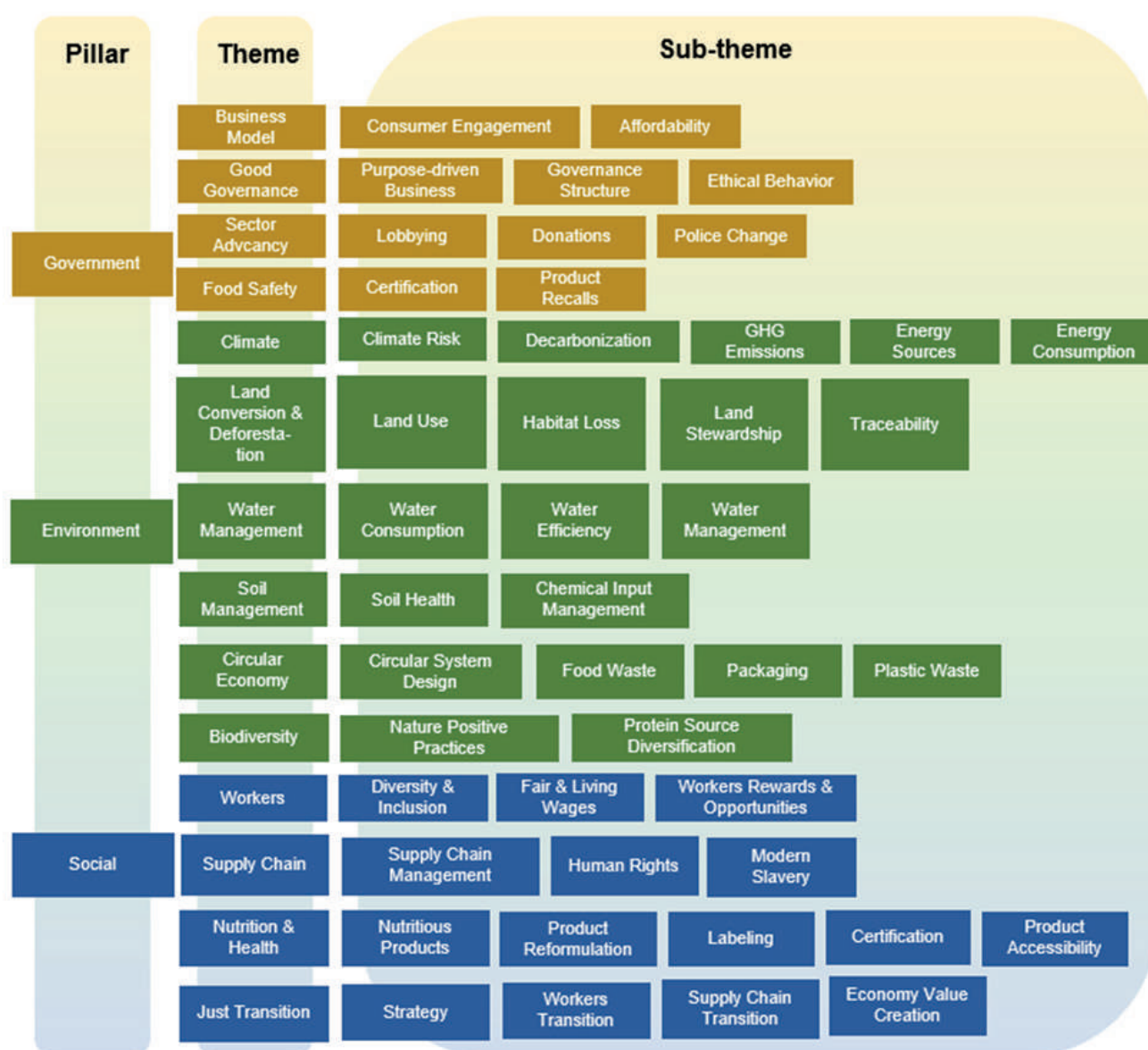


Figure 1: Framework structure GFI & FAIRR for alternative Proteins (adapted by Hussein (2023), based on Herd et al. 2022, p. 21).

Additional and more in depth analysis of this and similar frameworks was then carried out. Insights from interviews with stakeholders along the supply chain in terms of what opportunities and challenges they saw in the industry were explored and are in a forthcoming journal paper submission by the project team.

Key Insights and Next Steps

As outlined above, the pea protein market is experiencing an above average growth rate (from a relatively low base), compared to other alternative protein-based products. This makes it an attractive market to enter. However, as demand increases, so the supply becomes more difficult to meet. During this research project we spoke to various stakeholders along the supply chain from seed growers through to product manufacturers. Simply put, there are several reasons for not being able to meet end consumer demand. This situation is encapsulated by Roquette – a market leader in the pea protein processing industry – who warned of significant upcoming shortages in pea processing capacity. Furthermore, pea protein manufacturers face high raw material costs and low processing outputs (Bashi et al. 2022). This makes sense when one considers that only approximately 40% of a pea by volume can be feasibly sold at a profitable price. The starch which makes up the bulk of a pea currently attracts low prices. Other value streams need to be created to change this situation. A further problem is food security-related. Geopolitical tensions in Europe (especially the war in the Ukraine) meant that wheat growing became more strategically important (Economist, 2022), at the cost of other crops such as peas.

Frameworks and tools to evaluate the environmental, social and governance impact within the food industry, and also more narrowly in the alternative protein sector, are being developed and used. As the sector matures, these use cases need to be evaluated to determine the lessons learned. This will provide a deeper understanding of the longer term economic potential of pea protein-based products. This in turn will provide useful scenarios for the key stakeholders end to end along the supply chains.

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TOWARDS GREEN DISTRIBUTION ALTERNATIVES FOR CONSUMERS: THE INFLUENCE OF DEPENDENCIES BETWEEN ACTORS

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Introduction

E-commerce distribution is considered as the most inefficient and polluting part of the supply chain (Mangiaracina et al., 2015). To remedy this situation, there is an increasing interest for green distribution alternatives to consumers. Such alternatives would enable consumers to make environmentally sustainable choices when shopping online. Encouragingly, consumer interest in green distribution alternatives is, indeed, on the rise. For example, Ignat and Chankov (2020) suggest that consumers are more likely to choose a distribution alternative displayed as sustainable than one that is not. For retailers, the offering of green distribution alternatives can both lead to a competitive advantage, as well as leading to lower environmental impact. While there is a widespread interest among retailers, they struggle in terms of what to offer and how. For example, trustworthiness of what is labelled as green distribution at the checkout is considered problematic due to the difficulties in assessing and comparing environmental impact (Sallnäs and Björklund, 2023). To overcome such barriers, retailers to a large extent depend on other actors. For example, dependencies appear between retailers and logistics service providers (LSPs), who are the ones performing the actual deliveries to consumers' preferred delivery locations (Buldeo Rai et al., 2019). The details into dependencies between retailers and other actors are yet to be studied, which is why the purpose is to illuminate dependencies between actors in the development towards green distribution alternatives for consumers.

In the next section, a review of the literature is presented, after which the methodology is described. After that, preliminary results are provided, followed by concluding remarks.

Literature review

The literature review consists of three sections: 1) green distribution in e-commerce, 2) actors relevant for the context of e-commerce, and 3) dependencies between logistics actors.

Green distribution in e-commerce

In e-commerce, distribution alternatives are an important part of the customer offer and involves multiple actors that direct or indirect have an impact on the development of distribution alternatives for consumers. Retailers typically offer multiple distribution alternatives in their checkout, which consumers can choose between. There are typically five distribution alternatives associated with e-commerce: 1) "Click and collect", 2) pickup points, 3) locker stations, 4) home delivery, and 5) in-car delivery. These distribution alternatives are typically performed by logistics service providers on behalf of retailers.

In general, previous research on green distribution has focused on different green distribution strategies, including mode selection, the use of alternative fuels, improving fill rates, eco-driving, transport planning (see e.g. Isaksson and Hüge-Brodin, 2013; Pieters et al., 2012; Wolf and Seuring, 2010). For instance, Pieters et al. (2012) presented a categorisation of environmental practices for LSPs, including internal optimising (e.g. eco-driving and increased fill rates), external optimising (e.g. improved delivery planning, improved cooperation within the supply chain), internal innovating (e.g. new software applications and longer vehicles), and external innovating (e.g. developing new delivery services and cooperating with competitors).

In terms of green distribution in e-commerce, Sallnäs and Björklund (2020) adopted an early framework by McKinnon and Woodburn (1996) on different levels of logistical decision making and recognized that patterns of sourcing and distribution (i.e. the choice of distribution alternative), scheduling of production and distribution flows (i.e. the frequency and size of deliveries), and management of transport resource (i.e. decisions including choice of transport mode, routing, and vehicle technology), are three important decisions related to green distribution in e-commerce. Another example is Halldórsson and

Wehner (2020) who studied distribution alternatives in regard to their energy efficiency based on the three components: transport execution (i.e. commercial and private transportation, mode, vehicle size and type), distribution structure (i.e. shipment origin, point of reception, attributes of the delivery process, actor involvement), and household logistics capability (i.e. active or passive role of the end consumer). The authors identified four proposition that are essential for energy efficiency in green distribution alternatives, including: 1) high fill rates in vehicles; 2) avoidance or minimisation of private transport; 3) a pull approach is favoured to avoid unnecessary transport, and lastly 4) commercial trucks need to deliver goods collectively to pick-up points close to the household or locker stations, at central hubs that are passed by the end consumers on a regular schedule. Despite many studies into the environmental impact of e-commerce, Sallnäs and Björklund (2023) found a wide range of barriers for retailers in their attempts to offer green delivery alternatives for consumers.

Actors involved in the development of green distribution in e-commerce

Green distribution in e-commerce involves multiple actors. Several previous studies (such as Buldeo Rai et al., 2019; Halldórsson and Wehner, 2020; Sallnäs and Björklund, 2020), have focused on three main actors focus on three main actors; retailers, LSPs and consumers. While these actors might be the most evident, there are more actors that can be involved in e-commerce distribution. In an urban context, Kiba-Janiak et al. (2021) mentioned residents and government, in addition to shippers (producers and retailers), receivers (e-customers) and LSPs.

Furthermore, Kiba-Janiak et al. (2021) stated that green distribution alternatives can be viewed from three different perspectives, including: the demand side (demand for goods purchased online, such as individual consumers), supply (delivery of goods purchased online, represented by transport companies, LSPs, courier, express and parcel companies, and e-commerce services, producers and online shops) and the physical environment regulated by local and national authorities. These perspectives need to be considered in order to successfully develop green distribution alternatives in e-commerce.

Dependencies between actors

In terms of dependency and green distribution, Sallnäs (2016) suggested the existence of dependencies between LSPs and shippers in the development of environmental practices in general, and that both actors' environmental ambition was of relevance for coordinating environmental practices and developing green distribution. Further, Rogerson and Sallnäs (2017) showed internal dependencies in companies aiming for high load factors, one important measure to decrease environmental impact from logistics operations. While dependencies can be described in several ways, this paper relies on the categorisation of Thompson (1967), who distinguishes between three types of interdependencies; pooled, sequential and reciprocal. Pooled interdependence means that each part renders a discrete contribution to the whole and each is supported by the whole" (p. 54). Next, for sequential interdependence to occur, one part must act before a second part can act. The order in which events takes place is thus of importance for this interdependency. Finally, reciprocal interdependence includes situations in which the outputs of each become input for the others" (p. 55). The paper at hand takes these three types of interdependencies into consideration in the study of dependencies between actors. According to Thompson (1967), there is a hierarchy between the three types of interdependencies that he proposes. Pooled interdependence is always present in situations which also have sequential interdependence, and similarly, both pooled and sequential interdependence arise in contexts in which reciprocal interdependencies also can be identified.

Methodology

Following the purpose of this paper, i.e. to illuminate dependencies between actors in the development towards green distribution alternatives for consumers, a qualitative approach was applied. A qualitative approach, more specifically the case study methodology, was deemed powerful to establish an empirical understanding of the actors relevant in e-commerce distribution and the dependencies between them. Two case studies of retailers and related actors were conducted.

Case selection

The case selection started with the identification of relevant retailers following the logic of intensity sampling (Patton, 2015). Two retailers, Retailer A and Retailer B (see Table 1), were selected based in their high ambition to offer green distribution alternatives for consumers, their willingness to provide both information and help in coordinating with additional actors of

relevance. Retailer A is a forerunner in sustainability within Swedish retail and have reached out to the university to ask for guidance on green distribution alternatives; Retailer B already had ongoing interaction with the university, in which its high sustainability ambitions have become apparent. Two LSPs (LSP A and LSP B) were selected based on recommendations from the retailers. The chosen LSPs are among the largest players in terms of last-mile solutions in Sweden and are highly involved in numerous e-commerce and sustainability forums and projects involving actor such as retailers and governments. LSP A is specialised in e-commerce distribution, and LSP B, have e-commerce distribution as one of several offerings to retailers. A delivery platform provider was chosen as it operated the retailers' checkout, where distribution alternatives (including green distribution alternatives) are presented. In line with Flyvbjerg's (2006) guidelines, "information thickness" was an important selection criterion and the case companies had rich information related to the development of green distribution alternatives.

Company	Industry	Respondent
Retailer A	Pharmaceutical retailer	Director of logistics development
Retailer A		Business developer e-commerce
Retailer A		Director of sustainability
Retailer B	Sports wear and sports equipment	Supply chain director
Retailer B		Sustainability coordinator
LSP A	Specialised in e-commerce distribution	Business developer
LSP B	E-commerce distribution as part of a larger offer	Sustainability director
LSP B		Key account manager
LSP B		Corporate Client Director
Delivery platform provider	Provides retailers with a delivery platform, in which delivery options are shown to consumers	Chief Technical Officer

Table 1: Overview of case companies and respondents

Data collection and analysis

Empirical data was mainly collected through semi-structured interviews. The interviews were complemented with information retrieved from visits at the retailers' webpages, and workshops with the retailers. In terms of interviews. A total of 10 respondents were interviewed (see Table 1). Respondents at the retailers and LSPs were selected based on their involvement in green distribution. An interview guide was sent in beforehand to the respondents, including questions related to the checkout and development of green distribution alternatives. All interviews were recorded and transcribed. The transcribed material was also reviewed by the respondents to avoid misinterpretation.

After the data collection, the data analysis was performed in two steps: First, relevant actors were identified. Next, the analysis was made using the lens of interdependencies, i.e. pooled, sequential and reciprocal.

Preliminary results

According to the empirical data, a number of actors are relevant for retailers to be able to offer green distribution alternatives for consumers. Most apparent are perhaps the retailers themselves, as these are the ones who offer distribution alternatives to their customers. In line with, e.g., Sallnäs and Björklund (2020), LSPs also have a vital role for green distribution alternatives to be developed. Consumers are also of relevance, albeit with a more peripheral role in the development of these green alternatives. The results also illustrate some additional actors of relevance. One important actor appears to be delivery platform provider, a type of company used by many retailers in Sweden for the display of their distribution alternatives for consumers. Another relevant type of actor is external organisations who offer different types of labels for, for example, green distribution alternatives.

The offering of green distribution alternatives to consumers is a complex matter, which has been shown by, e.g., Sallnäs and Björklund (2023). The preliminary results for this paper point to the complexities that exist, as there are multiple actors

involved and several different ways for a retailer to tackle the development of green distribution alternatives. The results also illustrate several interdependencies between actors in order for green distribution alternatives to be developed, including both pooled, sequential and reciprocal interdependencies. Below, one example of each is provided.

Pooled interdependence is the simplest form of interdependence (Thompson, 1967), and the results point to this type of interdependence being present in the context of green distribution alternatives. It is evident that there are several actors that have an influence on the development of green delivery options. For example, retailers need to make decisions about which alternatives to offer as “green”. When doing so, they often rely on LSPs to provide information of different sorts, such as emissions data. Retailers also often rely on delivery platform providers, who facilitate the offering of different distribution alternatives through their platform. If one of the actors were to leave that constellation, that would not have a large effect on the possibilities to offer green delivery alternatives, which strengthens the finding that, seen from a wide perspective, there are pooled interdependencies in the context of green distribution alternatives.

Sequential interdependence appears when one actor has input for another actor, and when the order of the events is crucial (Thompson, 1967). There appears to be few such examples in the empirical data, but one example is the interdependence between external label organisations, LSPs and retailers. If a retailer decides to trust an external label enough to offer it as a green distribution alternative to consumers, the order of events appears to be quite straightforward, in a sequential manner. The external label organisation develops a label (this is a complicated task that is not part of the sequential example), which it offers LSPs to be able to adhere to. Once this is done, the LSPs, in turn, can offer retailers their services with the label attached. The retailers can accept, and, in turn, offer distribution alternatives to consumers with the green, externally validated, label. For some retailers, this might be the way forward. It demands relatively low effort for the retailers, and they are still able to offer green alternatives for consumers.

As for reciprocal interdependencies, these appear to exist when the “truly” green distribution alternative is to be found. One example includes Retailer A, and its struggle to be able to offer green distribution alternatives. Several actors have been involved in this work. In order to evaluate the most environmentally sustainable alternative, the retailer relied on the expertise of a consultancy firm. The retailer first required emissions data from its contracted LSPs, which were then given to the consultancy firm. The latter ended up with a comparison of the different distribution alternatives offered by Retailer A, and based on that, the retailer decided on which alternative to offer as the greenest. Next, back-and-forth communication with Retailer A’s delivery platform provider made possible the actual offering of the green distribution alternative to consumers on the webpage. However, the retailer cannot rely on the chosen alternative to be the greenest for all eternity but must validate and recalculate in order to be sure to offer the most environmentally sound option. New emissions data needs to be required from LSPs and new calculations and decisions need to be made.

Concluding remarks

By studying dependencies between actors in the development towards green distribution alternatives for consumers, this paper has an ambition to pinpoint the many and sometime complex dependencies that exist between the actors involved in the e-commerce context. While the paper is a work-in-progress, the preliminary results do show potential in highlighting the interdependencies that exist between relevant actors, thereby contributing with an increased understanding for retailers, LSPs and other actors in their strive to offer green distribution alternatives for consumers. Further, the paper aims to add to the small, but growing body of research into logistics taking the consumer perspective into account.

As the results are preliminary, the next step is to conduct a more in-depth analysis of the empirical data, to, for example, find interdependencies for different types of green distribution alternatives, or between specific types of actors.

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LOGISTICS INTERVENTION IN FOOD REDISTRIBUTION

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Introduction

Sustainability in the food supply chain has garnered extensive attention from actors in the food chain, government institutions and researchers (e.g., Chauhan et al., 2021; Garrone et al., 2014, 2016; Midgley, 2014; Papargyropoulou et al., 2022; Sundin et al., 2022) in recent years. The effects of the COVID-19 pandemic and the Russian-Ukrainian war have heightened concerns about improved global food security. The rise in the cost of living has also resulted in an exponential rise in the number of people who rely on alternative supply chains for their total or supplementary food supply. In the UK, both the Trussell Trust and the Independent Food Aid Network (IFAN) have reported almost a tripling of people using their services over the past decade (IFAN, 2023; Trussell Trust, 2022). The alternative supply chains that supply food to marginalised populations are dominated by non-profit and non-governmental organisations that rescue or recover surplus food in commercial food supply chains and redistribute to these disadvantaged groups. As these supply chains are humanitarian, they are fraught with many of the identified challenges with logistics operations and funding in humanitarian logistics research. However, research specifically addressing how these challenges manifest uniquely in the food aid and redistribution sector is severely lacking. In fact, the fundamentality of effective and efficient logistics operations to surplus food redistribution (SFR) is barely acknowledged.

In this paper, we argue that logistics interventions that lead to efficient, sustainable, and resilient food aid supply chains can accentuate the criticality of logistics and supply chain management in serving disadvantaged populations. First, we present a review of the literature on logistics in SFR and highlight various challenges presented. We identify the gap in the limited examination of the challenges to logistics operations and the solutions provided. Our data collection and analysis processes are discussed and our findings are presented. We then propose the operationalisation and funding of a logistics intervention based on our findings and highlight its sustainability implications for governments and corporations. We show how logistics and supply chain management insights can contribute to achieving the United Nations' Sustainable Development Goals 2 (Zero Hunger), 12 (Responsible Consumption and Production) and 13 (Climate Action). By highlighting these linkages, we seek to encourage corporate donors (of both funds and food), as well as governments, to acknowledge that funding the improvement of logistical operations has immense economic, social, and environmental sustainability benefits.

Logistics in Surplus Food Redistribution

The prevention of food waste has received increasing attention due to new insights into its impact on the environment. Scherhauser et al. (2018) show that 186Mt of CO₂-eq emissions, representing only 15 to 16% of the total impact of the entire food supply chain, are attributable to food waste in Europe. Tonini et al. (2018) in their study of food waste in the UK found that the carbon footprint per tonne of food waste ranged between 2000 and 3600 kgCO₂-eq. Although the prevention of surplus food is undoubtedly the most appropriate option, surplus food is inevitable, thus, necessitating discussions on effective and efficient SFR (Sawyerr and Bourlakis, 2022a; Thapa et al., 2021). This is particularly critical because there is also increasing food insecurity in the wake of the effects of recent events such as Brexit, the COVID-19 pandemic and the ongoing Russian-Ukrainian war.

To prescribe actionable changes and innovations in current SFR supply chain operations, it is necessary to unravel the complexities of the relationships between food donors and charitable redistributors. Thapa et al. (2021) and Sawyerr and Bourlakis (2022b) map the supply chain infrastructure and processes for food redistribution and highlight various operational challenges that lead to ineffectiveness and inefficiencies. Some of these challenges include labour fragility (such as an overreliance on voluntary labour and few critical personnel), difficulty in ensuring financial sustainability, competition among redistributors, and the lack of a policy framework to encourage and guide SFR. Furthermore, the informal relationships

between donors and redistributors, the uncertainty of food availability, costs, and the limited capacity and collaboration in the food aid supply chain all lead to various types of waste including food, time, labour, and funds. These have both direct and indirect implications on logistics operations.

Various solutions have been proposed to address identified challenges in SFR. Sundgren (2020) proposes an improved understanding of the supply chain by managers in commercial food supply chains and highlights the potential for reputational and economic benefits in reducing waste and improving surplus recovery. Sawyerr and Bourlakis (2022a) propose how different actors in both commercial and food aid supply chains could improve collaboration, operational efficiency, and awareness training. They also highlighted the need for increased economic incentives for both donors and redistributors and improved livelihoods and support systems for disadvantaged groups. Logistics operations are fundamental to SFR, as is in other humanitarian logistics operations (Gustavsson, 2003). Garrone et al. (2014), for instance, emphasise the criticality of logistics excellence to SFR by highlighting the impact on technical feasibility and the economic sustainability benefits, as well as cost-effectiveness for the food aid sector. However, studies specifically focused on actionable logistics interventions in SFR are woefully lacking.

In humanitarian logistics studies, many authors have identified the hesitance of donors to fund logistics operations and/or donor-derived perceptions and demands that drive humanitarian organisations to underfund logistics operations. Gustavsson (2003) and Thomas & Kopczak (2005) highlight how donor funding practices inhibit humanitarian organisations from tackling logistical inefficiencies. Dictates on fund usage by donors drive humanitarian organisations to focus on short-term direct relief and distribution, rather than long-term investment in logistics systems and processes (Oloruntoba and Gray, 2006). The proclivity of donors to fund emergency relief in the response phase of the disaster management cycle, but not in logistics infrastructures and processes during the preparedness phase, has also been identified as adversarial for humanitarian logistics operations (Jahre and Heigh, 2008). In fact, donors rarely specifically consider logistics in their funding decision-making (Majewski et al., 2010). Therefore, these factors have shaped the perception of humanitarian organisations of the expectations of donors. These influence their operational decisions, as they perceive donors to prefer their funds to be used for procurement rather than for logistics and assets (Turrini et al., 2020).

The lack of funding in humanitarian logistics operations is also present in the food aid supply chains that redistribute surplus food. Humanitarian practitioners and donors have been asked to consider logistics in the same light as procurement expenditure (Turrini et al., 2020). Indeed, investments in logistics operations could lead to better use of donor funds (Jahre and Heigh, 2008). Donors have therefore been encouraged to broaden their funding scope to include serious investments in infrastructure and personnel for improved logistics operations (Gustavsson, 2003). Supply chain researchers have also been encouraged to disseminate the discipline's concepts in a way that convinces humanitarian donors of the criticality and value of logistics and supply chain investments as much as tangible relief supplies (Oloruntoba and Gray, 2006). This study seeks to respond to this call, as the continued bemoaning of donor apathy toward logistics investments persists. It seeks to prescribe a clear logistics intervention strategy for improved SFR to help address the gap in the literature, prescribe a pathway to improved logistics operations in SFR, and also elucidate the related sustainability benefits to induce the funding of the logistics intervention.

Methodology

We conducted interviews with a total of sixteen senior managers from organisations in the commercial food supply chain (including primary producers, wholesalers, food processors, retailers, and logistics companies) and seven senior managers from the food aid supply chain. Additionally, we interviewed seven industry experts, academic professionals, and two government officials. The data collected from these interviews were then analysed using an abductive approach, with a specific emphasis on examining logistics challenges related to food redistribution and exploring potential solutions to address these challenges.

Findings and Discussions

Marginalised communities are served by a hybrid food supply chain, within which commercial food supply chain actors act as suppliers of donated food to redistributors. Redistributors may be food aid wholesale distributors (FAWD) (e.g., FareShare, UK Harvest, His Church, City Harvest, The Felix Project, SOFEA) or food aid service organisations (FASOs) (e.g., schools, foodbanks, community markets, cafés, etc.). The former accesses large amounts of donated food and distributes to

the latter for access by targeted disadvantaged groups. SFR is fraught with a myriad of challenges, many of which are related to logistics. We present the most critical ones in the following.

Logistics Challenges in Surplus Food Redistribution

Cost is a major logistical challenge for both donors and redistributors serving disadvantaged groups. Insufficient capacity and operational inefficiencies further compound the logistical challenges in food redistribution. These are explained below.

Cost

Some large donors (e.g., manufacturers and retailers) are reluctant to optimise their stock management systems to accommodate handling surplus food due to investment costs. Those who use the storage facilities of logistics companies are also hesitant in disposing of aged or unsold stock due to the potential impact on their profit/loss records. Relatively smaller donors (e.g., farmers) explore alternatives for their surplus food as they avoid the distribution costs associated with charitable donations and are also able to recoup some of their production costs.

For redistributors, these costs may be for transportation and/or processing. Some donated foods require repackaging and labelling based on donor or legislative requirements. These costs constitute a large portion of the expenditure of redistribution organisations. One FAWD manager said: “It’s incredibly expensive. Our largest expense by a huge margin is moving food around the country.” Funds from donations, grants, and membership fees (for social supermarkets) are usually inadequate to sufficiently cover these costs.

Insufficient Capacity

Redistribution companies face a variety of constraints that limit their capacity to deliver. They suffer high staff turnover and overly rely on volunteers whose numbers, availabilities, and capabilities are inconsistent – leading to high dependency on few core individuals and limited working hours. An interviewed government official said ...there’s a lot about capacity; some don’t even work seven days a week... Manufacturers, retailers, etc., they want a professional service. Anonymised redistributor, for instance, have only just got a massive fridge.” With limited funding and logistics expertise, many of these organisations do not have the relevant equipment and know-how to handle the volumes of surplus food that could be available to them, particularly considering the high perishability of donated food. These create vulnerabilities in the food aid chain, with many food aid service organisations folding up, thereby creating high variability in demand due to the high rate of closures and start-ups of consumer-facing charities that serve disadvantaged groups.

Operational Inefficiencies

SFR is fraught with inefficiencies in logistic operations. Disjointedness and limited collaboration resulting from limited transparency, mistrust, vertical and horizontal competition, unawareness, and limited online presence were identified as causes. Furthermore, inherent in the current SFR model is a supply-demand mismatch. Seasonal fluctuations in products and donations, the weather’s impact on primary production, and product shelf-life differences result in high variability in both the volume and type of products supplied to redistributors. Furthermore, high turnover in charities serving disadvantaged groups also affects demand, as wholesale redistributors then sometimes struggle to find where to send donated food. Decision-making bureaucracies between donors and their logistics service providers also cause delays, which heighten the pressure to process and consume donated food quickly before expiration.

Consequential Challenges

The major challenges described above create further logistical challenges. They make planning difficult, limit consumer choice, and hinder meeting peculiar consumer dietary needs. They lead to unnecessary process complexities and compromised food quality. Particularly worrying is that these can lead to both deliberate and inadvertent greenwashing by donors. Varying qualities of donated food, the reluctance to decline donated food even if undesired, unusable, or nearly expired in the fear of losing future support and the outright offloading of unwanted food items by donors all lead to redistributors having to send significant portions of donated food – up to 40% in some cases (Alexander and Smaje, 2008) – to waste.

Logistics Intervention

A pivotal finding from our study is the very limited role logistics companies play in SFR. They currently offer discounts to some large FAWDs and fulfil the delivery demands of their customers' redistribution requests. We argue here that logistics companies are primally placed to intervene and transform logistics in SFR.

Logistics companies specialise in the provision of storage and distribution services for all actors in the commercial food chain. WRAP reported that manufacturers and retailers were responsible for 78% of the redistributed surplus in 2021, with Hospitality and Food Service accounting for an additional 10% (WRAP, 2022a). Therefore, the logistics companies that serve these organisations are strategically positioned to detect surplus food early and improve visibility for both donors and redistributors on the handling of surplus food. With a streamlined decision-making protocol in place, the transfer of surplus stock from commercial inventory into the redistribution chain will be easier, traceable, and reduce delays. Redistributors will receive products with longer shelf-life to ease processing pressures. As these logistics companies provide services simultaneously for multiple actors in the food chain, they will have access to a more diverse range of food products to offer FAWDs, helping to mitigate supply-demand mismatches, reduce uncertainty with food provision, better serve peculiar consumer dietary needs, broader consumer choice, and provide better quality food. Their intervention will further reduce procedural complexity, eliminate waste activities and delays, and improve efficiency, as the distribution of surplus food to redistributors from different suppliers can be consolidated. Their intervention will also greatly address greenwashing. In affirming the practicality of this intervention, an interviewed logistics company senior manager said: "We have the infrastructure to do it collectively. Our company has the skills and capabilities to design what the solution should look like and the most optimal way of doing it, and indeed the most cost-effective way of doing it. And in between us, we could come to an agreement as to how that cost would be paid for".

As the interviewee indicates, the described logistics company intervention must be funded. We present some additional propositions on addressing these in the following.

Funding Logistics Intervention in SFR

At present, many large donors already pay for delivery to redistributors. With our proposed intervention, redistributing surplus from multiple donors will be more efficient and cost-effective. As redistribution saves donors landfill disposal costs and has implications for both their social and environmental sustainability reporting, funding redistribution should be incentivising. For primary producers and donors operating on relatively thinner margins, government support is needed to cover logistics costs. Customers of primary producers (e.g., manufacturers, wholesalers, and retailers) can also cover logistics costs for redistribution, as this will reduce food loss and waste and related emissions in their supply chains. Furthermore, redistribution can be encouraged through tax reprieves tied to waste prevention so that reducing waste and increasing redistribution becomes an attractive alternative to animal feed and anaerobic digestion. Finally, logistics companies can also cover part of the redistribution costs as a corporate social responsibility.

In the food aid supply chain, funding towards logistics infrastructure and equipment investment should be prioritised, particularly from government sources. This can be used to enhance collaboration among FASOs as they can be encouraged to bid for government funds jointly. An interviewed government official revealed that "...some charities struggled to apply for the grants that we were offering" while others complained of unfair funding as recounted by another official "...they still complained to me, 'They (another charity) are getting all the money'". Encouraging joint fund application will reduce currently unhealthy competition and ensure that more FASOs have improved storage capacity.

Post-Covid, charities have reported a shift in funding away from logistics operations support toward community engagement programmes (aimed at addressing food insecurity), making it more difficult to access direct funding for logistics. Inasmuch as the latter is important, food rescue & redistribution is the backbone upon which the community-engagement programmes are run. Thus, undercutting logistics funding necessarily makes community engagement programmes unsustainable as reduced food availability will hinder current accessibility to these communities. Both government and corporate funding of food aid logistics operations is critical for any meaningful resolution of food inequality and insecurity challenges.

Sustainability Implications of Logistics Intervention in SFR

Our proposed logistics companies' intervention in SFR will lead to more accurate reporting on food redistribution particularly with the oversight participation of bodies such as the Food and Drink Federation, the Institute of Grocery Distributors, and

the Cold Chain Federation, among others. Therefore, government bodies will better implement incentive schemes to reduce food waste and improve SFR. For businesses, their sustainability reporting will not only be more accurate but will also have greater validation.

Environmentally, increased food redistribution necessarily means reduced food waste and associated adverse environmental impacts. von Massow et al. (2019) estimated that a weekly average of 2.98kg of food waste was equivalent to 23.3kg of CO₂. Thus, the avoidance of the approximately 0.95Mt of edible food waste as estimated by WRAP (2022b) in manufacturing and production alone could lead to significant environmental gains. Furthermore, with increasing pressure for companies to be more responsible for their Scope 3 emissions (which includes indirect up- and down-stream emissions in their supply chains) (Huang et al., 2009), ensuring edible surplus food, right from pre-farmgate to consumption are redistributed for human consumption is desirable. With the replacement of the Common Agricultural Policy with schemes such as the Environmental Land Management Scheme, farm businesses are increasingly focusing on sustainability, and carbon emissions are becoming a tradeable unit. By preventing food waste through improved redistribution, thus reducing Scope 3 emissions, powerful food supply chain actors, such as retailers and manufacturers, can drive mutually beneficial sustainability goals across the chain. This will also help minimise greenwashing.

Improving SFR has multiple social benefits, including improved physical and mental health, as well as social and emotional well-being (Nayak and Hartwell, 2023). As our proposed solution will lead to efficient SFR, food quality will necessarily improve. While SFR may not be the ultimate solution to food insecurity, it is a potent long-term solution to using surplus food and preventing waste, regardless of the socioeconomic status of the consumer. However, with increasing food insecurity, it is a critical social remedy. Additionally, there is growing evidence in gastroenterology for the link between the gut microbiome (the collection of microorganisms, including bacteria, viruses, fungi, and other microbes, that reside in the digestive tract, primarily the large intestine) and human physical and mental health (Cheung et al., 2019; Valdes et al., 2018; Yang et al., 2019). As fibre consumption has been associated with beneficial effects on the gut microbiome (Leeming et al., 2019; Valdes et al., 2018; Visconti et al., 2019), a properly functioning logistics operations in SFR, which will ensure increased fruit and vegetable consumption among the most vulnerable – who disproportionately suffer diet-related health conditions (Munro et al., 2023) – cannot be understated.

These social and environmental sustainability implications also have economic sustainability implications, the most obvious of which is the savings that businesses make by avoiding landfill disposals. More significantly, however, is that SFR leads to quantifiable economic and social value which should thus incentivise both government and corporations to ensure the backbone operations – which is logistics – are well funded and efficient. Nicholas et al. (2023) revealed FareShare's work creates a net economic and social value of £225 million, of which savings directly to the UK were approximately £118 million. If extended to other independent food redistributors such as UK Harvest, Company Shop, His Church, and City Harvest, among others, both the state and beneficiaries of SFR reap significant value that should justify both academic and financial attention for optimisation.

The implications presented above show the critical role efficient, properly funded and managed SFR logistics and supply chain operations can play in the achievement of three United Nations Sustainable Development Goals, namely 2 (Zero Hunger), 12 (Responsible Consumption and Production; specifically, target 12.3) and 13 (Climate Action).

Conclusion

Adding on to previous studies that discuss the infrastructure and processes of the hybrid food supply chain that supplies food to marginalised groups, this paper focuses on logistics challenges in the operations of these supply chains, discusses how an enhanced role of logistics companies in SFR could lead to significant sustainability gains for both donors and redistributors, as well as governments and the overall community. Having engaged practitioners and experts in both the commercial and food aid supply chains, as well as academic experts, our propositions are realistic and actionable. We clearly outline a variety of ways that the proposed logistics intervention can be funded and have expounded on the specific benefits for the various actors. Its practical and policy implications for both governments and corporations have also been highlighted. This paper answers the call for academic practitioners to help justify the urgent need to finance logistics operations in the third sector.

Notwithstanding, there are limitations which require further research and complementary interventions. For example, additional interventions are required to facilitate this proposed redefined role for logistics companies and to address the

challenges downstream of the food aid supply chain. The new role can address operational inefficiencies, the consequential challenges outlined, and partly address the insufficient capacity challenge between donors and FAWDs. However, it does not adequately address the insufficient capacity of FASOs. In fact, should the intervention be successful, even more surplus food will be available for redistribution, as WRAP reports that 173 large producers and manufacturers wasted 949 kilotonnes of edible food in 2022 (WRAP, 2022b). Thus, the limited logistics capacity downstream of the food aid supply chain must be addressed.

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FROM SAFETY MEASURE TO BIG DATA SOURCE: A REVIEW OF AUTOMATIC IDENTIFICATION SYSTEM LITERATURE

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Introduction

In 2000, the United Nations specialized agency responsible for the maritime sector, the International Maritime Organization (IMO), amended Chapter V of the International Convention for the Safety of Life at Sea (SOLAS). With the initial intention to reduce collisions and grounding risk, the IMO mandated in SOLAS Chapter V Reg. 19 that vessels above 300 gross tons (GT) on international services, vessel above 500 GT, and all passenger ships irrespective of size were obligated to install an AIS transceiver by 31st December 2004. These AIS transceivers transmit information about vessel identity, position, and other status messages to other vessels in the vicinity, onshore receiver stations, as well as satellites on a regular basis. Initially, AIS technology was introduced to detect and identify vessels on highly frequented waterways, as traditional visual imaging and radar applications alone displayed serious limitations. Over time, governmental and commercial run AIS data management platforms amassed a critical amount of big data that enabled to shift the initial focus of AIS from safe navigation of vessels to a multitude of further applications from observing single vessel operations to quantify overall maritime traffic (Yang et al. 2019; Kanamoto et al., 2021).

So far, reviews about AIS tend to be incomprehensive, as they either focused on certain areas like anomaly detection techniques (Sidibé and Shu 2017; Wolsing et al., 2022), development of AIS applications (Fournier et al., 2018; Svanberg et al. 2019) or dealt with AIS just in a wider context of big data and/or artificial intelligence (Munim et al., 2020, Gorman et al., 2023). Others like Meyers et al. (2021) conducted a Scopus-based bibliometric study to map research output and extent of collaboration among researchers utilizing AIS. Accordingly, the aim of this paper is not only tracking research output but exploring publication trends and themes of AIS research since its early beginnings as well as discussing obstacles of AIS data handling.

Methodology

The paper follows a systematic literature review (SLR) approach (Durach et al., 2017) to explore the full body of scholarly publications dealing with AIS through the last two decades. However, as initial sampling via two scientific databases resulted in a massive volume of publications for further inspection, bibliometric analysis was employed in later stages as a rigorous method for exploring and analysing large volumes of bibliographic data (Donthu et al., 2021).

To cover a wide variety of potential publication outlets, both Web of Science (WoS) and Scopus were employed, as WoS is renowned being more selective in its journal coverage, whereas Scopus covers a wider range of journals (Zhu & Liu, 2020; Singh et al., 2021). The initial sampling procedure was kept as open as possible, to catch all possible publications dealing with AIS. Accordingly, a rather unrestricted initial search string in WoS was “ALL = (“automatic identification system” OR ais)” and “TITLE-ABS-KEY (“automatic identification system” OR ais)” in the case of Scopus with inclusion of articles and reviews written in English, and finally published in scholarly journals for the years 2000–2022. Due to the revision of SOLAS Chapter V Reg. 19 took place in 2000, establishing a need for a time horizon prior to that year has been rejected. Furthermore, publications originating from the domains of medicine, pharmacy, physics, chemistry, sociology, psychology, philosophy, and earth sciences were discarded, especially due to the fact that in all of these contexts, AIS was used as an abbreviation for other term like “Artificial Immune System”, “Adolescent Idiopathic Scoliosis” or the alike.

This resulted in an initial sample of 2,556 publications from WoS and 2,730 from Scopus for further inspection along publication title, abstracts, and keywords provided by them. During a manual screening process, missing data was added, and terminology was aligned to end with a merged, refined sample of 1,735 publications with bibliometric information drawn 1,097 times from WoS and 638 from Scopus as of 6th July 2023. Main reasons for discarding publications at this stage was again that AIS was used as an abbreviation with a total other meaning in the context of accounting, engineering, informatics, sports, agriculture, or geo sciences.

Bibliometric Analysis

To analyse this refined sample, the R-package Bibliometrix (Aria & Cuccurullo, 2017) was employed. In the following, firstly overall publication trends are shown, before research output by countries, authors, and affiliation as well as publication themes and main topics are mapped over two decades based on bibliographic data.

Overall Publication Trends

Between 2000 and 2022, 1,709 articles and 26 reviews published by 4,278 (co-)authors in 451 different journal outlets with a compound annual growth rate of 25.89 % could be identified. However, only 5.88 % of them were published before 2011 with declining total citations per publication and year (TCPA) thereafter from a maximum of 87.5 TCPA in 2011 as depicted in Figure 1. In this respect, it can be asserted that until 2011, AIS was rather a niche topic and thereafter, a steadily increasing number of publications were published with much less impact than before.

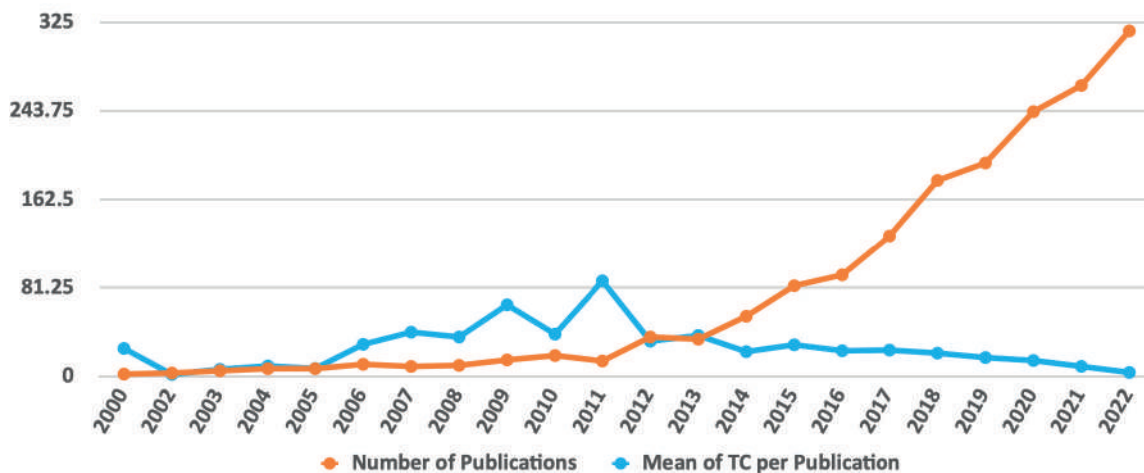


Figure 1: Number publications and total citations per publication and year 2000-2022

As shown in Table 1, domain of main journal outlets by number of publications and total citation (TC) counts is a mix of marine engineering, navigation, and remote sensing with a focus on technical challenges in AIS usage and those where AIS is deployed as a big data source for studies about social, environmental, and economic aspects in the wider domain of maritime, ocean or coastal studies (and even beyond). Other journal outlets dedicated to these research fields that made it not in the top ranking of Table 1 are, e.g., Transportation Research Part D with 19 publications since 2017, Transportation Research Part E with 11 since 2015, Maritime Policy & Management with 10 since 2017, Journal of Coastal Research with 10 since 2018, Maritime Economics & Logistics with 7 since 2014, and Transport Policy with 6 since 2019.

In terms of other citation metrics, both h-index (Hirsch, 2010) and g-index (Egghe, 2006) indicate that productivity and impact of articles and reviews published are rather high in terms of TC for most of these journal outlets listed in Table 1. The h-index counts the top h publications by TC that received at least h citations and so rewards a consistent stream of publications with lasting and above-average impact (Hirsch, 2010), whereas the g-index is defined as the unique largest number such that the top g articles received together at least $2g$ citations so that highly cited publications bolster low-cited ones (Egghe, 2006).

Table 1: Most relevant journal outlets 2000-2022

Journal Outlet	# of Publications	TC	h-index	g-index	Year of 1st Publication
Ocean Engineering	134	3,650	34	56	2010
Journal of Navigation	113	2,549	28	47	2000
Journal of Marine Science and Engineering	81	477	13	18	2018
Sensors	49	766	14	26	2014
TransNav	45	79	4	8	2014
IEEE Access	44	434	10	19	2017
Remote Sensing	36	597	15	23	2009
Marine Pollution Bulletin	34	993	16	31	2007
Frontiers in Marine Science	32	379	10	18	2017
Marine Policy	30	561	14	23	2015
Reliability Engineering & Systems Safety	27	1,216	20	27	2009
Ocean & Coastal Management	23	356	11	18	2017
Sustainability	23	155	7	11	2015
IEEE Transactions on Intelligent Transport Syst.	21	571	11	21	2017
Science of the Total Environment	20	690	13	20	2012

Research Output by Countries, Authors, and Affiliation

Starting with author's affiliations (as recorded by WoS and Scopus), a clear cluster of researchers from People's Republic of China is obvious. In total, 495 publications (or 28.55 %) have at least one author affiliated from there with 140 publications (or 28.28 %) including a collaboration with co-authors from abroad. When it comes on research output by affiliation, Wuhan University of Technology and Dalian Maritime University are in front, followed by Shanghai Maritime University (see Table 2, double counting of publications occurs due to co-authorships).

On author level a rather high concentration is apparent, too, with 3,184 (74.4 %) of all authors contributing to only one publication, whereas 12 authors contributed to 20 and more publications. Testing against Lotka's Law about frequency distribution of scientific productivity (Lotka, 1926), our value of 2.41 ranges well between 1.78 and 3.78 for most research disciplines (Pao, 1986). When it comes on the most productive and impactful research work in terms of TC, researchers affiliated with Aalto University (Pentti Kujala), Finnish Meteorological institute (Jukka-Pekka Jalkanen, Lasse Johansson, Jaako Kukkonen) and Dalhousie University (Floris Goerlandt, Kristina Boerder, Boris Worm) are in the lead as shown in Table 3. Moreover, the by far most cited articles are Kroodsma et al. (2018) tracking the global footprint of fishery vessel fleets with 473 total citations (TC) and a staggering 78.83 TCpa, and Bruschi et al. (2011) about ship surveillance on open sea by satellite-based synthetic aperture radar (SAR) with 340 total citations (or 26.15 TCpa) as of 6th July 2023.

Overall, it can be stated that research in AIS technology and its application is a standalone research domain, with a high degree of (co-)authorship and concentration centred around a close-knit core group of authors and affiliations.

Table 2: Research output by author's affiliation

Author Affiliation	# of Publications	% of Publications	# of Publications p.a.	Year of 1st Publication
Wuhan University of Technology	249	14.35%	20.75	2010
Dalian Maritime University	170	9.80%	14.17	2010
Shanghai Maritime University	114	6.57%	19.00	2016
Aalto University	52	3.00%	4.00	2009
Dalhousie University	50	2.88%	3.85	2009
Wuhan University	49	2.82%	4.08	2010
Nanjing University	47	2.71%	11.75	2018
Delft University of Technology	42	2.42%	3.50	2010
Universidade de Lisboa	41	2.36%	5.86	2015
National Taiwan Ocean University	38	2.19%	2.38	2006

Table 3: Research output by author

Author Name	TC	TCpa	# of Publications	h_index	g_index	Year of 1st Publication
Kujala, Pentti	1,471*	113.15	25	17*	25	2009
Goerlandt, Floris	1,313	119.36	21	15	21	2011
Kukkonen, Jaako	891	68.54	6	6	6	2009
Zhang, Yudong	854	142.33	29	16	29*	2016
Johansson, Lasse	833	83.30	14	10	14	2012
Jalkanen, Jukka-Pekka	826	63.54	12	9	12	2009
Guedes Soares, Carlos	755	107.86	17	13	17	2015
Boerder, Kristina	724	120.67	8	6	8	2016
Worm, Boris	684	114.00	7	6	7	2016
Meng, Qiang	682	62.00	13	9	13	2011
Zhang, Wei	678	96.86	17	12	17	2015
Montewka, Jakub	674	84.25	13	9	13	2014
Kroodsma, David A.	669	133.80	5	4	5	2017
Liu, Rian Wen	635	127.00	16	13	16	2017
Li, Ying	602	66.89	20	11	20	2013

Publication Themes and Main Topics

This last step of the bibliometric analysis aims to identify main topics and development of themes or thematic clusters over time. Given that 9.3% of keywords by authors as well as 32.4% keywords created by WoS and Scopus were missing for the refined sample of 1,736 publications, further analysis was done based on bigrams (i.e., a contiguous sequence of 2 words) drawn from the publication abstracts of 1,728 publications (for the reminder, no abstract was available). Furthermore, to obtain a clearer picture about publication themes and topics, bigrams including variations of the initial search strings were discarded before further analysis.



Figure 2: Word cloud of bigrams derived from publication abstracts

Figure 2 depicts the resulting word cloud of bigrams for all 1,728 publication abstracts, where we see that bigrams including the terms “traffic”, “collision”, “trajectory”, “detection” and “emissions” are quite dominant topics mentioned there.

When mapping co-occurrence of these bigrams by its associated strength (Aria & Cuccurullo, 2017), five thematic clusters with distinct overall themes can be identified shown in Figure 3:

- Cluster 1 mainly consists of bigrams including the terms “traffic”, “collision”, “trajectory”, so that the main theme can be characterized as dealing with more technological aspects of AIS aiming on the safe navigation of vessels.
- Cluster 2 is dedicated to ship detection by means of synthetic aperture radar (SAR) as a complement to AIS to increase coverage in remote coastal areas and on open seas.
- Cluster 3, where AIS data from several vessels located in defined areas is accumulated to measure fuel consumption of vessels, crowding effects of marine traffic like resulting underwater noise impacting sea animals.
- In Cluster 4, the main theme is measurement of ship emissions originating from vessel operations that causing severe air pollution.
- Cluster 5 finally deals with observing fishing activity by tracking fishing vessel fleet operations and its impact on sea food population close to coastline and on open seas.

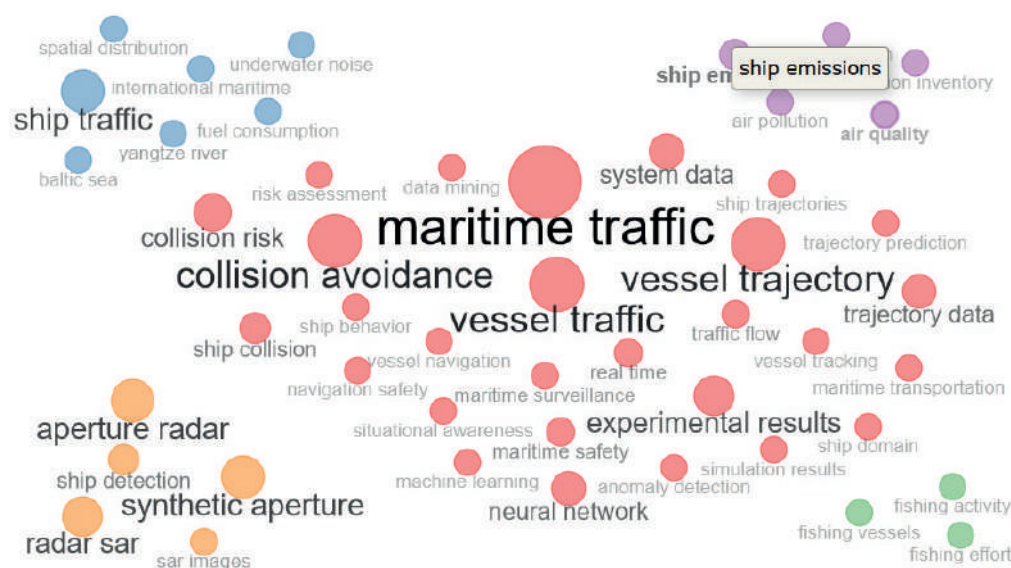


Figure 3: Clustering of bigrams derived from publication abstracts

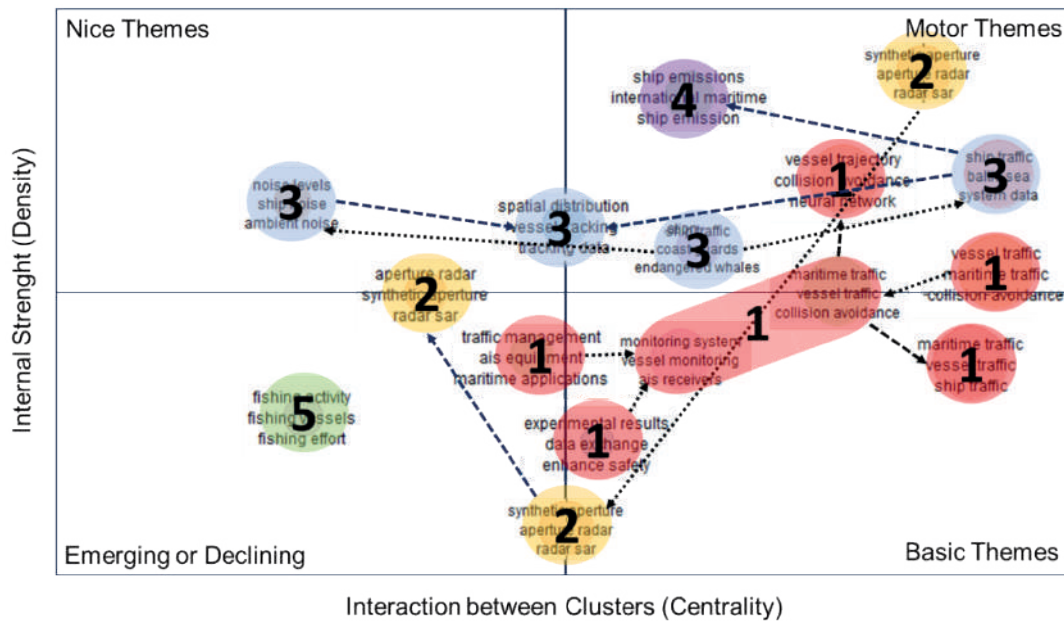


Figure 5: Thematic evolution of clusters over time 2000-2022

Finally, thematic evolution of these five clusters over three consecutive subperiods (namely 2000-2011, 2012-2016, 2017-2022) is visualized based along degree of interaction of one cluster with another (centrality) and internal strenght (density) in form of a two-dimensional thematic map (Cobo et al., 2011). Using bigrams in abstracts in our context, centrality is about their common appearance across several clusters and density express to what extent they appear only within a certain cluster. As shown in Figure 5, Cluster 1 (safe navigation) tends to be an all-time basic theme with high attraction and ever new contributions, whereas Cluster 2 (ship detection) turns out to be a strong motor theme before 2011 that declined heavily 2012-2016 to be regarded thereafter as a well developed nice theme of less interest outside in 2017-2022. Cluster 3 (ship traffic) starts as a rather weak motor theme, splits up 2012-2016 into two branches dealing either with niche themes like ambient noise or very central themes around ship traffic observations and reunites lateron. Finally, Cluster 4 (ship emissions) and Cluster 5 (fishing activity) are virtually non-existent until 2017-2022 with the first being a spinn-off of Cluster 3 characterized by high density of publications and the later a emerging but rather marginal and isolated theme in the context of AIS.

Discussion

A diversification of AIS applications is visible, which raises also the question about its data quality (Fournier et al. 2018). Ships fitted with AIS transceivers are obliged to always maintain their operational status, according to SOLAS Chapter V Reg. 19 Subsection 2.4.7. Certain exceptions provide the protection of navigational information, such as international agreements, rules, or standards. In such cases, it requires that the occurrence should be noted in the ship's logbook. Despite that, erroneous data in AIS datasets do exist quite regularly. Several practical cases pointed to illegal activities where AIS transceivers sent false (spoofed) signals or were deliberately turned off (Androjna et al., 2021; Aubry et al., 2021; Wolsing et al., 2022). In par, international standards and penalties for delivering unreliable AIS quality data are not in place (Adland et al., 2017). An addition to this, also inaccuracies are well known accruing from weak signal transmission to satellite failures. Prior studies noted that the quality of AIS data relates heavily to AIS transceiver quality (Aarsæther & Moan, 2009, Last et al., 2015), present vessel location (Zhang et al., 2018), onshore receiver location (Zhao et al., 2018), satellite constellation and orbit (Eriksen et al., 2018), as well as human errors while imputing manually voyage-related information about planned destination (Yang et al., 2021) or current draught (Fournier et al., 2018). Finally, there is a lot of anecdotal evidence about erroneous static information in AIS big data concerning vessel characteristics like IMO number, current vessel name, type and/or dimensions unveiled by triangulation it with other sources. Hence, analysis of AIS big data needs cautious treatment as it is by far flawless.

Conclusions

In this paper, journal literature published from 2000 to 2022 dealing with AIS technology was reviewed based on bibliometric data from WoS and Scopus. The study identified that research activity in this domain is substantial with 1,735 articles and reviews finally published in scholarly journal outlets but so far quite concentrated concerning main journal outlets, authors, and their affiliations. Furthermore, themes and main topics underwent several shifts over time with a focus on technological aspects in 2000-2011, that turns to a vessel movement or fleet tracking perspective in 2012-2016, and thereafter a steadily increasing number of publications emerged using AIS big data for other purposes like evaluation of social, environmental, and/or economic impacts of vessel movements or traffic flows in the wider domain of maritime, ocean or coastal studies (and even beyond). When it comes on limitations of this study and so an outlook for further research, a deeper dive into text content and references cited would be worthwhile to get a better overview how AIS technology can be further applied in research efforts.

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SUSTAINABLE SUPPLY CHAIN PERFORMANCE OVER THE PAST DECADE: A REVIEW OF DEFINITIONS, THEORY AND MEASUREMENT

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1. Introduction

In recent years, there has been increasing attention given to sustainable supply chain performance (SSCP) as traditional indicators of efficiency and effectiveness alone are no longer sufficient to evaluate supply chain success. This paper aims to explore methods for enhancing supply chain performance within the context of sustainability, recognizing the shifting paradigm in the field. The study conducts a systematic review of the theory of SSCP and examines evidence for further developing this area of research.

The prioritization of SSCP in supply chain management is driven by studies emphasizing the significance of resilience, sustainability, and integrated performance metrics. Early work by Elleuch et al. (2016) integrated sustainability into the quality function deployment approach, leading to improved production resilience. Subsequently, Balfaqih et al. (2016) called for a comprehensive revision of traditional supply chain performance metrics, advocating for the inclusion of environmental impact, social responsibility, and long-term sustainability. Building upon this foundation, Maestrini et al. (2017) redefined supply chain performance metrics, promoting a more holistic evaluation system.

Recent research has brought about a transformation in understanding supply chains. Barakat, Tipi, and Wu (2023) suggest viewing supply chains as interconnected clusters optimized for sustainability rather than independent entities, which has enhanced overall performance. Additionally, Nagariya, Kumar, and Kumar (2022) recognized the unique nature of service-only supply chains and stressed the importance of assessing their sustainability. They developed a framework considering the complexity and specific challenges faced by these supply chains. Given these advancements, studying SSCP is critical for ensuring supply chain resilience in the face of environmental, social, and economic changes, and for highlighting the overall benefits of sustainability. By facilitating the development of efficient, profitable, and socially responsible supply chains, the study of SSCP contributes to a more integrated and sustainable perspective on supply chain performance. This study aims to expand and refine the discussion surrounding SSCP, building upon the established foundation of previous research.

2. Research Methodology

The review process involved collecting peer-reviewed scholarly articles from Scopus between 2013 and April 2023 using specific search parameters. More than 400 documents were initially identified based on titles, abstracts, and keywords. After refining the search and applying exclusion criteria, a selection of 100 relevant peer-reviewed journal articles was made. Data extraction was then conducted using Microsoft Excel, with the primary author extracting general information such as publication date and journal for descriptive analysis. Thematic analysis was applied to classify the selected articles and identify main themes and findings, ensuring consistency in description and interpretation through comprehensive review by the co-authors.

3. Descriptive Analysis

Figure 1 depicts a distribution of publications over time for a subset of the articles in the sample that was analyzed, which reveals a publication increase trend. The distribution indicates that the discipline is emerging rapidly. As depicted in Figure 2, the majority of sample projects employ survey research methodologies. Resource-based view (RBV) is the most commonly employed theory. Typically, the manufacturing industry and sector context is the focus of the sample project (see Figure 3). However, nine of the papers concentrate on the food industry, while the remaining eight focus on a different context. Current comprehension of identified barriers focuses primarily on manufacturing, the food industry, information technology, and market management.

Figure 1 : Distribution of Publications over time

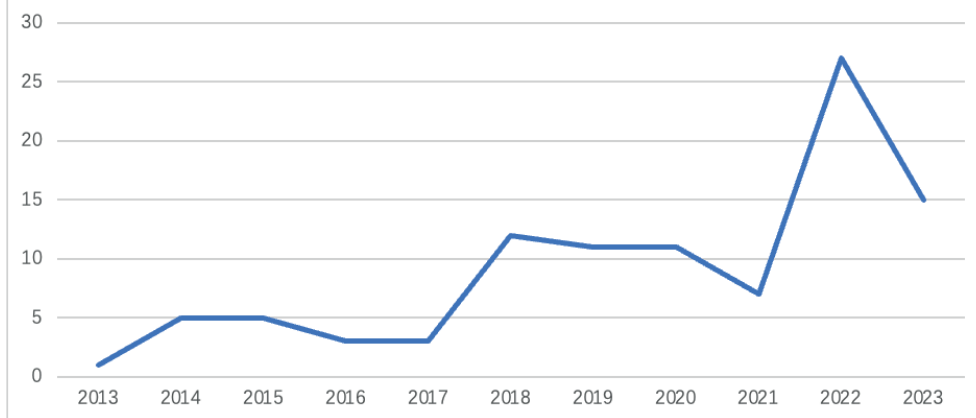


Figure 2

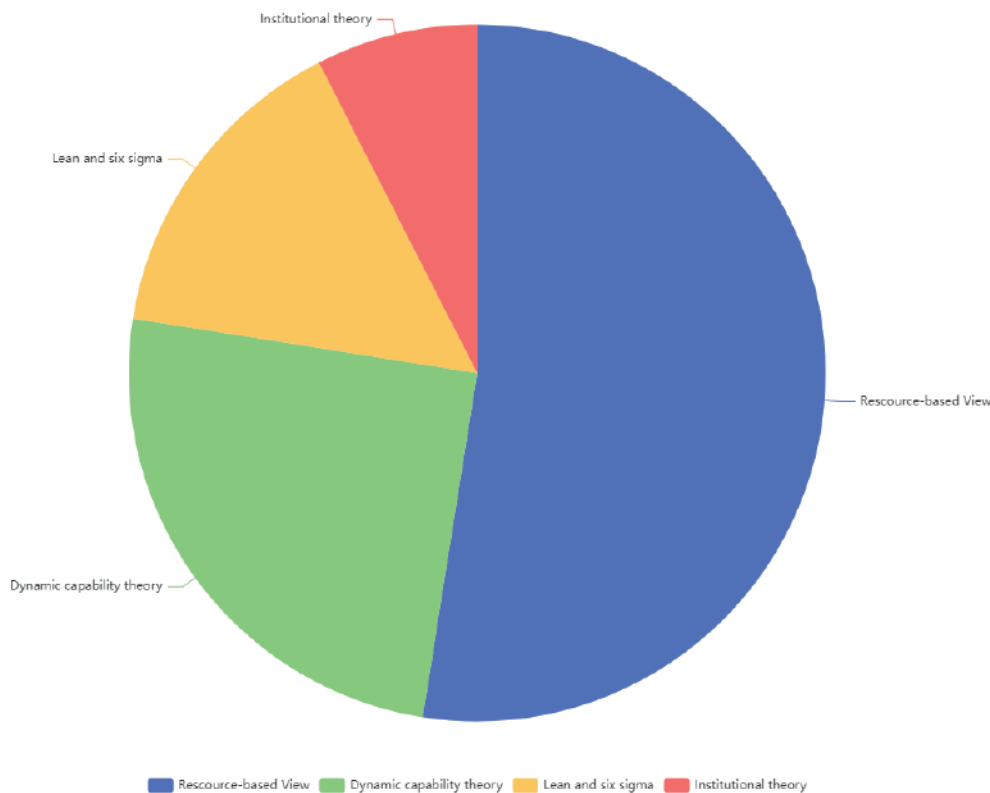
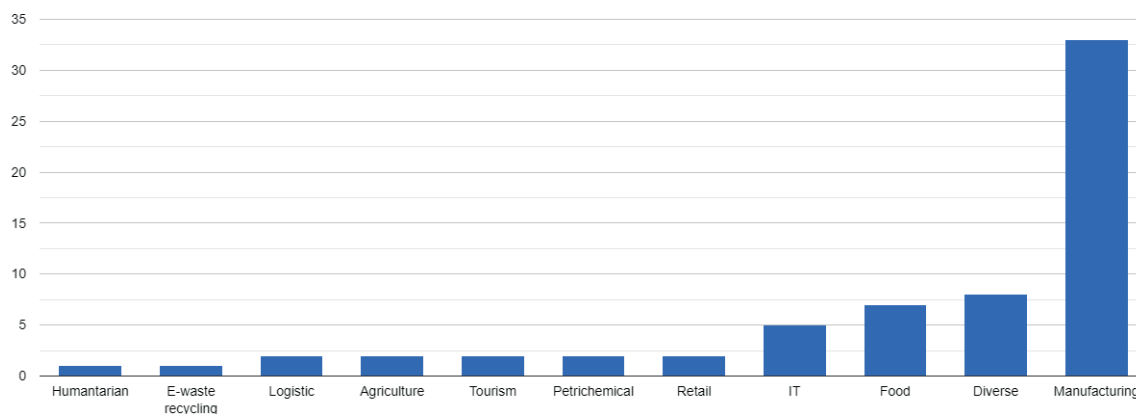


Figure 3



4. Thematic analysis of SSCP measurement

4.1. Conceptual Understanding

When analyzing supply chain integration and sustainability performance, it is essential to perceive the interplay between internal and external factors and to adopt a balanced perspective. It is evident from Wiengarten and Longoni's (2015) research that operational and sustainability performance enhancements are the result of successful supply chain integration, which requires both collaborative and cooperative practices. These practices facilitate the sharing of key environmental and social performance data based on mutual trust and ensure the alignment of all partners' processes and protocols. In the meantime, Arda et al. (2021) emphasize the need for a broader understanding of sustainability, casting light on the internal-external fit. This viewpoint emphasizes the need for companies to align their internal resources and capabilities with external sustainability initiatives in order to optimize performance. Consequently, it is essential that performance metrics capture not only the internal resources of a company, but also their synchronicity with external sustainability requirements, thus encompassing the broader context of sustainable supply chain management.

4.2. Sustainable Supply Chain Performance Indicators: A Comprehensive Overview

Supply chain performance is a critical factor in an organization's operational efficiency and overall success. To comprehensively assess performance, it is important to consider multiple indicators, with sustainable supply chain performance indicators standing out due to their impact on economic, environmental, and social dimensions (Qorri et al., 2020; Kitsis & Chen, 2020). Agyabeng-Mensah et al. (2020) highlighted four essential indicators: Green and Sustainable Practices, Logistics Optimization, Social Value and Ethics, and Economic Performance. These indicators measure the incorporation of environmentally friendly practices, logistical and transportation management efficiency, commitment to ethical labor practices, and financial viability of supply chain operations, respectively, highlighting the critical importance of sustainability.

Expanding on this perspective, Bahrami et al. (2022) introduced the Innovation and Technology Adoption Indicator, which evaluates the use of advanced technologies like AI, blockchain, and Industry 4.0 in supply chain operations. This indicator acknowledges the rising trend of digitalization and automation in modern supply chains. Additionally, the supply chain resilience indicator, based on the dynamic capabilities theory (Pu et al., 2022) and defined by Cardoso et al. (2015), assesses the supply chain's ability to recover from disruptions and maintain continuity.

Organizational culture also plays a significant role in sustainable supply chain performance, as noted by Osei et al. (2023). The Organizational Culture and Sustainable Performance Indicator considers the dynamics between culture and performance. Furthermore, the Lean and Efficiency Practices Indicator evaluates the implementation of lean practices in the supply chain, focusing on waste reduction and continuous improvement (Khanchanapong et al., 2014). The Supply Chain Integration Indicator, proposed by Wiengarten and Longoni (2015), assesses the level of collaboration among supply chain stakeholders, emphasizing the importance of integration for performance enhancement. The Supply Chain Visibility Indicator, introduced by Saqib and Zhang (2021), addresses supply chain transparency, including product monitoring and traceability. Lastly, the Competitive Advantage Indicator evaluates the contribution of supply chain practices to a company's competitive advantage, considering factors such as cost reduction, customer satisfaction, and market share (Pu et al., 2022).

4.3 Frameworks for SSCP Measurement

Supply chain performance is a critical factor in an organization's operational efficiency and overall success. To comprehensively understand and measure this performance, it is important to consider multiple indicators. Sustainable supply chain performance indicators have gained prominence due to their impact on the triple bottom line: economic, environmental, and social dimensions. Key indicators in this regard include green and sustainable practices, logistics optimization, social value and ethics, and economic performance (Agyabeng-Mensah et al., 2020).

The incorporation of environmentally friendly practices in the supply chain is measured by the Green and Sustainable Practices Indicator, which contributes to lower carbon emissions, waste recycling, and increased energy efficiency. The Logistics Optimization Indicator evaluates the efficiency of logistical and transportation management. The Social Value and Ethics Indicator gauges a company's commitment to ethical labor practices, equitable trade, and social responsibility. Economic performance refers to the sustainability and financial viability of supply chain operations.

In addition to these indicators, the Innovation and Technology Adoption Indicator introduced by Bahrami et al. (2022) evaluates the use of advanced technologies like AI, blockchain, and Industry 4.0. The supply chain resilience indicator measures the ability of the supply chain to recover from disruptions and maintain continuity (Cardoso et al., 2015). Organizational culture also plays a significant role in sustainable supply chain performance (Osei et al., 2023), leading to the inclusion of the Organizational Culture and Sustainable Performance Indicator.

Furthermore, the Lean and Efficiency Practices Indicator focuses on waste reduction and continuous improvement through lean practices (Khanchanapong et al., 2014). The Supply Chain Integration Indicator assesses the level of collaboration among supply chain stakeholders (Wiengarten and Longoni, 2015). The Supply Chain Visibility Indicator addresses supply chain transparency, including product monitoring and traceability (Saqib & Zhang, 2021). Lastly, the Competitive Advantage Indicator evaluates the contribution of supply chain practices to a company's competitive advantage (Pu et al., 2022).

4.4. Supply chain practices for SSCP

Current research in business and environmental studies emphasizes the significance of sustainable practices in supply chain management and their impact on organizational performance. The shift towards a greener business paradigm has underscored the importance of sustainable supply chain management practices in enhancing overall performance. Adesanya et al. (2020) highlight the positive relationship between supplier engagement in sustainability initiatives and supply chain performance in the tobacco industry. Agyabeng-Mensah et al. (2020) demonstrate the direct link between green warehousing, logistics optimization, and improved economic performance, emphasizing how incorporating sustainability principles into logistics operations can lead to cost savings, enhanced reputation, and increased customer satisfaction.

Moreover, Al-Khatib (2022) examines the technological implications and asserts that leveraging big data analytics capabilities can improve the performance of green supply chains by enabling real-time tracking and monitoring of environmental impacts. This facilitates strategic decision-making and promotes environmentally responsible practices. Likewise, Altay et al. (2018) emphasize the importance of agility and resilience for supply chain performance, particularly in humanitarian contexts, and argue that sustainable practices can enhance these characteristics.

Arda et al. (2021) and Baliga et al. (2020) highlight the competitive advantage and enhanced firm performance that result from sustainable supply chain management practices. Dzikriansyah et al. (2023) focus on the role of Green Supply Chain Management (GSCM) practices in improving environmental performance, specifically among Indonesian SMEs. El-Garaihy et al. (2022) advocate for sustainable supply chain management to foster inclusivity and responsibility in shaping the future.

5. Synthesis and gaps in future research

5.1 Barriers to improving SSCP

Improving the performance of a sustainable supply chain is a complex and intricate challenge organizations face today. These difficulties are exacerbated by numerous obstacles that make the transition to sustainable practices difficult and frequently met with opposition. As noted in the literature, some of these barriers can be categorized under four main themes: organizational, knowledge and technological, financial, and cultural.

Integration, collaboration, and alignment within the supply chain comprise the majority of organizational barriers. For operational and sustainability performance enhancement, as Wiengarten and Longoni (2015) have emphasized, a nuanced approach to supply chain integration involving both coordination and collaboration is required. In a similar vein, Agyabeng-Mensah et al. (2020) highlighted the importance of green warehousing and logistics optimization in this integration. However, accomplishing this alignment and integration is not a simple task, and is frequently impeded by rigid organizational structures and a lack of knowledge of sustainable practices. Osei et al. (2023) argued that a competing values framework can help improve sustainable supply chain performance by emphasizing the significance of organizational culture in this context.

In contrast, knowledge and technological barriers pertain to the supply chain's comprehension, adoption, and application of sustainable practices and advanced technologies. Nagariya, Kumar, and Kumar (2022) emphasized the need for a systematic literature review and conceptual framework for performance evaluation of service-only supply chains. Similarly, Qader et al. (2022) emphasized the role of Industry 4.0 in enhancing supply chain resilience and performance. However, the knowledge divide and the difficulty of adopting and integrating these technologies into existing systems are significant obstacles.

Significant costs associated with the incorporation of sustainable practices comprise the majority of the monetary obstacles. Although investments in green technologies and practices are beneficial in the long term, many organizations find it difficult to justify the upfront costs (Saqib & Zhang, 2021; Fekpe & Delaporte, 2019). This is especially true for small and medium-sized businesses, which may lack the capital to invest in sustainable practices.

Lastly, cultural barriers emphasize the difficulty of aligning the values, beliefs, and attitudes of individuals and groups within an organization with sustainable practices. Agyabeng-Mensah et al. (2020) have highlighted the significance of social values and ethics in improving economic performance. However, changing cultural norms and attitudes is a sluggish and difficult process that frequently encounters opposition.

5.2 Future research potential

Four promising avenues for future research in the area of sustainable supply chain performance emerge from the abundance of recent research on sustainable supply chain management.

The intersection of resilience and sustainability is ripe for future research (Vergara et al., 2023; Cardoso et al., 2015; Bahrami et al., 2022; Qader et al., 2022). Resilience enables supply chains to respond to and adapt to disruptive events, whereas sustainability ensures their long-term viability. Those supply chains that can successfully combine these two elements will attain superior performance and a competitive edge. Future research could build on this foundation by investigating resilience mechanisms that contribute to sustainability, and vice versa, in order to provide a more comprehensive understanding of supply chain dynamics in the face of disruptions and change. This involves comprehending how resilient, sustainable supply chains can mitigate the effects of disruptions and contribute to performance enhancement.

The impact of organizational culture and social values on sustainable supply chain performance is another burgeoning area of study (Osei et al., 2023; Agyabeng-Mensah et al., 2020). Understanding the relationship between these factors and how they facilitate or impede the integration of sustainability into supply chains is crucial. In addition, research examining how these elements interact with other organizational factors to affect supply chain sustainability outcomes could yield new insights into how to effectively integrate sustainability into supply chain operations.

Incorporating advanced technologies such as Big Data Analytics, Blockchain, and Internet of Things (IoT) into sustainable supply chain practices can improve supply chain visibility, traceability, and efficiency, and consequently, performance (Li et al., 2022; Raj et al., 2022; Qader et al., 2022). Future research can investigate the functions of these technologies, the barriers to their adoption, and the strategies for their successful implementation in the context of enhancing the performance of sustainable supply chains.

Ivo de Carvalho et al. (2022); Nagariya et al. (2022). Such frameworks would provide a more thorough comprehension of the actual performance of supply chains and aid in identifying areas for improvement. In addition, they would be a useful instrument for companies to compare their performance to that of their competitors and industry standards.

6. Conclusion

This review affirms the importance of sustainable supply chain performance (SSCP) to operational success and competitiveness in a world where sustainability is gaining increasing importance. It emphasizes the significance of integrating sustainability measures into supply chain practices, highlighting a paradigm shift. The complexity and dynamics of SSCP necessitate a multi-theoretical approach that combines insights from the resource-based view, the dynamic capability view, and institutional theory in order to provide a comprehensive understanding of the impact of firm-specific resources, adaptability, and external institutional forces.

Enhancing SSCP is hampered by obstacles such as organizational structures, knowledge deficits, financial constraints, and cultural norms. Defeating these obstacles is essential for attaining sustainability and resilience. Future research offers numerous opportunities, especially at the intersection of resilience and sustainability, the influence of organizational culture, and the role of advanced technologies. Improving our comprehension of SSCP and developing effective strategies for enhancing sustainability performance are of paramount importance in a world beset by environmental and societal challenges.

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SUPPLY CHAIN INTEGRATION AND IT COMPETENCY OF MARITIME ORGANISATIONS: THE ADOPTION OF BLOCKCHAIN TECHNOLOGY

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1. Introduction

In recent years, major shipping organisations have adopted blockchain technology (BTC) to integrate maritime supply chain for end-to-end service (Panayides and Song 2009). Shipping companies are developing BCT-based platform where encrypted data can be accessible to every party reducing inefficiency including time delay, human error, and miscommunication. Notwithstanding the diffusion of BCT application academic research of blockchain application in the maritime and shipping industry is still in fancy. While a wide range of literature has conducted conceptual and review analysis and provided valuable insights, there has been far less consideration in maritime sphere.

2. Literature review

2-1. Maritime supply chain integration

Supply chain integration (SCI) in the maritime and shipping sector has become a predominant strategy in response to changing customer needs. SCI denotes the extent to which a company effectively utilise its resources and capability in a collaborative manner with its channel partners. While early SCI focused on the linear relationship and flows between customers and suppliers more recent developments emphasise a non-linear network approach to integration (Fabbe Costes and Jahre 2008). SCI in maritime supply chain consists of Information sharing, Knowledge creation, Collaborative communication, Goal similarity, Decision harmonisation, Joint chain performance measurement (Seo et al. 2016). Information sharing among stakeholders facilitates seamless cargo flows in the maritime supply chain by contributing to visibility and exchanging relevant and accurate information (Heide and John 1992). Knowledge creation plays a vital role in the maritime supply chain by enabling participants to engage in inter-organisational collaboration, generating and acquiring integrated knowledge that empowers them to effectively mitigate uncertainty and adapt to the dynamic changes within the supply chain (Lee and Song 2010). Collaborative communication, serving as the foundation for integrated strategies within the maritime supply chain, facilitates interaction among stakeholders, enabling effective supply chain operations, strategic formulation, and decision making (Cao and Zhang 2011). Goal similarity in maritime supply chain refers to extend to which participants pursue common objectives, aiming to improve the efficiency and effectiveness of the entire supply chain (Ryu et al. 2009). This pursuit maximises the benefits derived from SCI. Through decision harmonisation, stakeholders strategically align transport planning and operations across the maritime supply chain, aiming to secure transport volume from external supply chains and foster mutual benefits in a competitive environment (Song and Panayides 2008). Jointly measuring and managing the performance of a supply chain contributes to the establishment of contingency plans and modifications in order to optimise the flow of cargos within the supply chain. It enhances visibility within the supply chain and enables the evaluation of collaborative efforts by diagnosing supply chain operations (Simatupang and Sridharan 2005).

2-2. IT competency

IT competency encompasses a firm's ability to gather, integrate, and utilise IT resources effectively in order to address business requirements and leverage potential business prospects. IT competency consists of flexible IT infrastructure, IT assimilation, managerial IT knowledge, and IT personnel skills considering supply chain context (Liu et al. 2016). Flexible IT infrastructure denotes a shared set of technological resources that form the foundation for the prompt development and implementation of both present and future IT applications (Terry Anthony Byrd 2000). IT Assimilation refers to a firm's

ability to effectively utilise IT to support, shape, and facilitate its business strategies and value chain activities. Top managers' managerial IT knowledge encompasses essential business acumen and technical skills to perceive the value and potential of IT and effectively employ it to align business processes with organisational goals (Lee et al. 1995). IT personnel skills denotes the technical capabilities of IT staff that assist companies in integrating IT platforms, data, and information systems to effectively address the challenges posed by the rapid growth and widespread adoption of innovation (Lee et al. 1995).

2-3. Blockchain adoption and utilisation

Blockchain utilise a decentralised network to maintain and track transaction data, with blocks in the chain linked by cryptographic hashes and all nodes having an identical copy. Once verified and validated by the parties involved in the transactions, blocks become immutable, ensuring transparency, traceability, security, and trust over the network. Data on a decentralised system can be accessed, monitored, stored, and updated by multiple participants, resulting in disintermediation of intermediaries and full visibility of transactions for supply chain members (Blossey et al. 2019). Based on a systematic literature review conducted prior to this study, the application of blockchain in the maritime supply chain has been identified and categorized into three domains based on specific roles and associated benefits: document management, transaction management, and cargo, vessel, and terminal operation.

2-4. Performance

In this study, the measurement of organisational performance entailed assessing the effectiveness of supply chain operations and the degree of financial benefits. Operational performance indicators included the speed, cost reduction, quality, and lead time within the supply chain. Financial performance was evaluated based on metrics such as return on investment, return on sales, market share, and net income, among others (Flynn et al. 2010).

3. Research method

A survey instrument was elaborated based on the literature review and conceptual framework developed from review analysis. SCI in maritime supply chain consists of Information sharing, Knowledge creation, Collaborative communication, Goal similarity, Decision harmonisation, Joint chain performance measurement. IT competency consists of flexible IT infrastructure, IT assimilation, managerial IT knowledge, and IT personnel skills considering supply chain context. Data was collected from a total of 334 samples within maritime organisations in Korea, including, shipping liners, terminal operators, forwarding companies, and port authorities. This study employed One-way ANOVA tests to examine the differences in blockchain adoption status among four groups of maritime organisations. Then, PLS-SEM method is deployed to examine the impact of IT competency on supply chain integration and supply chain integration on performance. Additionally, the research investigates the potential moderating(interaction) effects between the utilisation of blockchain technology in the relationship between supply chain integration and IT competency. Research model and hypothesis are established as followed:

H1: IT competency positively influences Supply chain integration.

H2-1: Supply Chain Integration positively influences operational performance.

H2-2: Supply Chain Integration positively influences financial performance.

H3-1: IT competency indirectly influences operational performance through its impact on supply chain integration.

H3-2: IT competency indirectly influences financial performance through its impact on supply chain integration.

H4: Blockchain technology adoption enhances the relationship between IT competency and Supply chain integration, leading to improved performance.

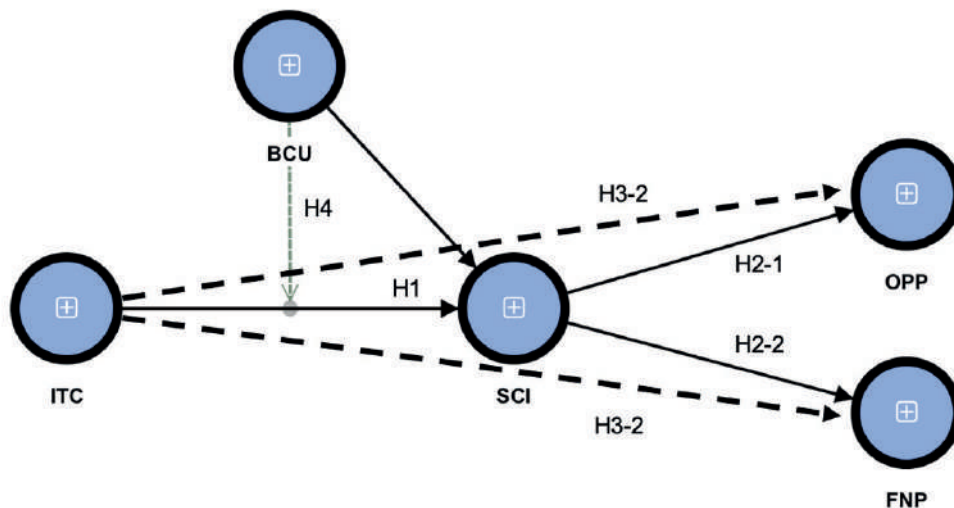


Figure1. Research model

4. Findings

A One-way ANOVA was conducted to examine the differences in the variable BCU among four groups (shipping liner, freight forwarder, terminal operator, port authority). The analysis did not revealed a significant effect of group on BCU.

Dependent valuable	Business type	N	Mean	SD	F	P
Blockchain Utilisation	Shipping Liner	78	3.819	1.585	1.974	.118
	Freight Forwarder	116	3.695	1.411		
	Terminal Operator	56	3.187	1.700		
	Port Authority	29	3.742	1.872		

Table. Differences in blockchain utilisation between the maritime organisations

As the next step, the questionnaire survey was conducted and the measurement model was assessed to establish the reliability and validity of the construct. All items in the model exhibited factor loadings greater than the recommended value of 0.70. Reliability analysis using Cronbach's alpha and composite reliability (C.R) yielded values exceeding the threshold of 0.70, demonstrating high internal consistency. Convergent validity was supported as the average variance extracted (AVE) exceeded the acceptable threshold of 0.50 (Hair et al. 2010). Discriminant validity was established by comparing the correlations among latent variables with the square root of AVE (Fornell and Larcker 1981). The correlations were lower than the corresponding AVE, confirming discriminant validity. Higher-order constructs were formed for SCI and IT competency, comprising 6 and 4 lower-order constructs, respectively. To establish the validity of these higher-order constructs, factor loadings, reliability, and convergent validity were examined. The indicators exhibited factor loadings higher than the desired threshold of 0.70, ensuring strong associations. Reliability analysis using Cronbach's alpha and C.R indicated values above 0.70, demonstrating good internal consistency for the higher-order constructs. Convergent validity was supported as the AVE for the higher constructs exceeded 0.50. Discriminant validity was established by comparing the correlations among latent variables with the square root of AVE. The square root of AVE for each construct was higher than its correlation with all other constructs, confirming discriminant validity.

Categories	Latent variables	No. items	Reliability & Validity		
			Cronbach's alpha	C.R	AVE
SCI	Information Sharing (IS)	5	0.907	0.931	0.729
	Knowledge Creation (KC)	5	0.89	0.919	0.694
	Collaborative Communication (CC)	5	0.897	0.924	0.708
	Goal Similarity (GS)	5	0.876	0.909	0.668
	Decision Harmonisation (DH)	5	0.871	0.906	0.659
	Joint chain Performance Measurement (JPM)	5	0.861	0.9	0.643
ITC	Flexible IT Infrastructure (FITI)	5	0.906	0.93	0.727
	IT Assimilation (ITA)	4	0.923	0.946	0.813
	Managerial IT Knowledge (MITK)	3	0.954	0.97	0.916
	IT Personnel Skills (ITPS)	5	0.953	0.964	0.842
BCA	Blockchain Utilisation (BCU)	4	0.968	0.977	0.914
PERF	Operational Performance (OPP)	6	0.94	0.953	0.771
	Financial Performance (FNP)	5	0.967	0.974	0.883

Table. Construct of questionnaire and Reliability / Validity

Following the assessment of the measurement model, the evaluation of structural paths and the examination of path coefficients were conducted. H1 aimed to investigate the significant and positive effect of IT competency on SCI. The results indicated a significant and positive impact of IT competency on SCI ($\beta = .562$, $t = 10.602$, $p < 0.000$), providing support for H1. Next, H2-1 and H2-2 examined the significant and positive effects of SCI on operational performance and financial performance, respectively. The findings revealed significant and positive impacts of SCI on operational performance ($\beta = .723$, $t = 19.965$, $p < 0.000$) and financial performance ($\beta = .656$, $t = 14.862$, $p < 0.000$), thereby supporting H2. Moving on to H3-1 and H3-2, the indirect effects of ITC on operational performance and financial performance through SCI were assessed. The analysis demonstrated that IT competency indirectly enhances operational performance ($\beta = .406$, $t = 9.658$, $p < 0.000$) and financial performance ($\beta = .369$, $t = 9.392$, $p < 0.000$) through its positive impact on SCI, providing support for H3. Furthermore, H4 examined the moderating effect of BCT adoption on the relationship between IT competency and SCI. The analysis revealed a significant positive interaction effect of BCT on the IT competency - SCI relationship ($\beta = .201$, $t = 4.510$, $p < 0.000$), indicating that the relationship between IT competency and SCI is strengthened when BCT is highly utilised. This finding supports H4 and suggests that BCT adoption acts as a moderator.

Hypothesis	Path	β	S.E	T	P
H1	ITC -> SCI	0.562	0.053	10.602	0.000
H2-1	SCI -> OPP	0.723	0.036	19.965	0.000
H2-2	SCI -> FNP	0.656	0.044	14.862	0.000
H3-1	ITC -> SCI -> OPP	0.406	0.042	9.658	0.000
H3-2	ITC -> SCI -> FNP	0.369	0.039	9.392	0.000
H4	BCU x ITC -> SCI	0.201	0.045	4.51	0.000

Table 3. Data analysis results

5. Conclusion

This study extends the existing contingency research on SCI and IT especially in the maritime sector. This research provides a significant academic contribution by examining the effect of blockchain technology on the relationship between SCI and IT competency. The study explores the moderating role of blockchain technology in this relationship, which is an area that has not been well-researched. The empirical findings of the study advance the current literature on supply chain integration and digitalisation by demonstrating the configuration of SCI-IT competency and potential of blockchain technology to improve supply chain processes and enhance overall performance.

However, it is important to acknowledge certain limitations of this study. One notable limitation is the relatively low adoption and utilisation of blockchain technology in the maritime sector, which may raise concerns regarding the generalisability of the research findings. The limited understanding of blockchain technology and its applications among the respondents is a potential limitation in this study. Furthermore, due to the rapidly evolving nature of blockchain technology, the current study's findings may have a limited shelf life. As blockchain technology continues to advance and mature, new developments and implementations may emerge, potentially impacting the observed relationships and outcomes.

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CUSTOMER ORIENTATION IN SUPPLY CHAINS – TOWARDS A CONCEPTUAL FRAMEWORK

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1 Introduction

Supply Chain Management (SCM) has for the past decades been a central concept in logistics research. The importance of effectively managing supply chains has been further increased by e.g., global supply chain complexity, a focus on sustainability and carbon footprint, and the need of resilience-related responses to supply chain disruptions. Research has indicated that management of supply chains is a means to address such challenges.

Two characteristics of SCM are the management of supply chains instead of single firms, and having a customer focus (Mentzer et al., 2001). Supply chain integration is considered central in SCM and Zacharia et al. (2009) state that “firms that have a deep understanding of their potential collaboration partner would be more willing to collaborate openly and intensely”. The understanding of customers is described by Hult et al. (2008) as customer orientation: “the sufficient understanding of a firm’s target customers to be able to create superior value for them continuously”. Further, Allred et al (2011) found customer orientation to be positively related to both customer satisfaction and productivity. This emphasizes the need of a more comprehensive understanding of the concept of customer orientation, and its relation with supply chain integration.

A firm’s orientation towards customers is prevalent in logistics and supply chain management, and there is a multitude of terms describing that orientation: achieving customer satisfaction; having superior customer service; fulfilling customer needs, demands and expectations; creating customer value; having a customer focus; being customer centric; and customer responsiveness. This paper focuses on the concept of customer orientation, which stems from marketing literature, as a set of beliefs that puts the customer’s interest first (Deshpandé et al., 1993), to continuously create superior value for the customers (Narver and Slater, 1990), and to obtain information from customers about their needs and preferences (Kohli and Jaworski (1990). The literature of market and customer orientation has a strong focus on the products. Logistics services, on the other hand, can provide firms with a competitive advantage. When a firm’s products as such cannot be distinguished from the competition, logistics capability is a source of differentiation (Ralston et al., 2013). The combination of product and service offerings is important to a firm, and thereby the internal integration between e.g., logistics and marketing as part of supply chain integration.

Hence, there is need of exploring and operationalize how customer orientation has been used in literature concerning logistics and supply chain integration. The purpose of this research is to build a conceptual framework by identifying categories of customer orientation and exploring the relations between customer orientation and integration in supply chains by applying the framework.

The paper continues by describing the research design, the literature review and the analysis behind the conceptual framework in section 2, followed by a brief introduction to supply chain integration (SCI) in section 3. Section 4 presents the categories of customer orientation, and section 5 discusses the framework with the relations between customer orientation and integration. Conclusions and further research are presented in section 6.

2 Research Design

In this paper we applied an approach inspired by Jakkola (2020) to develop a conceptual framework. We take a stance in that the focal concept SCI (supply chain integration) appears to have weak or missing explanations in how it relates to CO (customer orientation), seen here as a supplementary concept (ibid.). The area of exploration is how the concepts of CO and SCI relate to each other in literature.

SCI, in a broader perspective, includes external and internal integration, i.e., integration with suppliers and customers and integration between business functions within a firm. In each dyad in the supply chain the supplier may have a customer

orientation, and the customer a supplier orientation. Moreover, each firm may have internal orientation between different functions. In this paper we delimit the system to the relationship between a supplier and a buyer in a dyad, and CO relates to the supplier's customer orientation.

Originating from the concept of customer orientation in marketing literature, we focused our literature review on the use of the CO concept in logistics and supply chain literature and concerning integration or collaboration. The truncated search keys were found in either title, abstract or as subject. The final search string was: (TI "customer orient*" OR AB "customer orient*" OR SU "customer orient*") AND ((TI "supply chain*" OR AB "supply chain*" OR TI "logistic*" OR AB "logistic*") OR (TI "integration" OR AB "integration" OR TI "collaborat*" OR AB "collaborat*")). This resulted in logistics and supply chain-related articles on customer orientation, and integration and collaboration-related articles, respectively or both. Unisearch (a search engine at Linköping university) was chosen as the database, as it covers several databases with literature of relevance within social science, e.g., Business Source Premier, ScienceDirect, and Emerald Insight. Only peer reviewed, and full text articles were considered.

The search was performed systematically in several steps. The initial search identified 518 potential articles. Exclusion criteria (e.g., non B2B contexts, salesperson's CO) limited the sample to 107 articles, being read in full. The final twenty-seven applicable articles, predominantly survey articles, were analyzed to define categories of customer orientation. The result of the literature review is displayed in Figure 1, which shows what search keys were found in each article. Out of the twenty-seven selected articles, fifteen were considered as the most congruent in terms of definitions, perspectives, and content (bold references in figure 1).

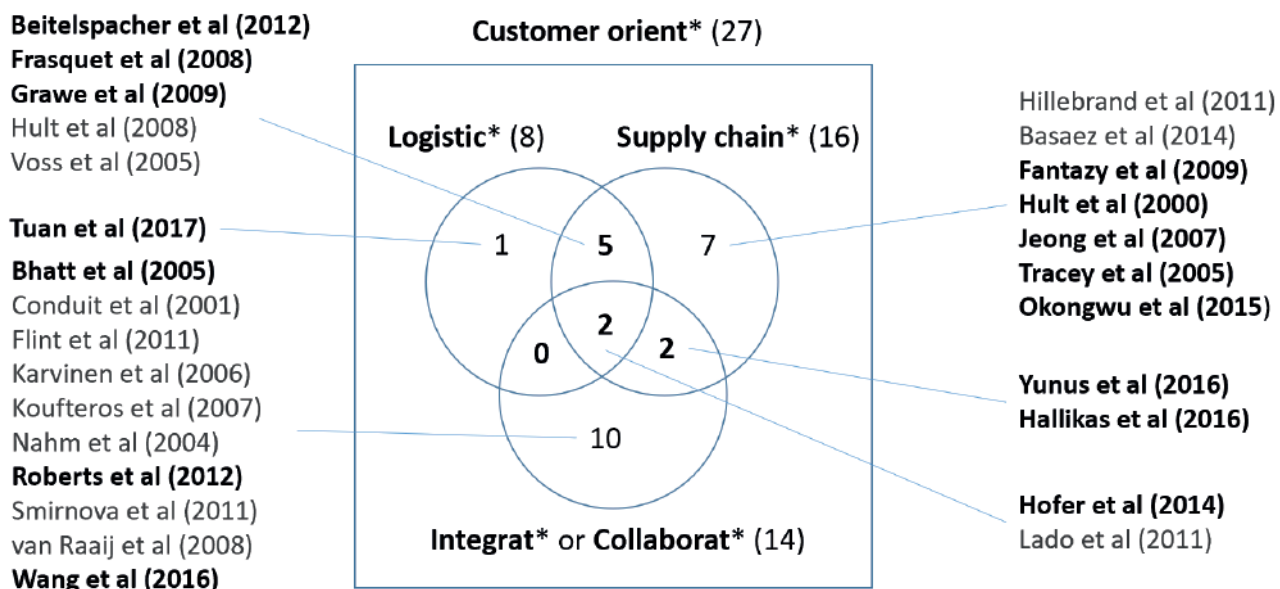


Figure 1: Results of the literature search.

To operationalize customer orientation, analysis of definitions of customer orientation (seventeen of the articles provided definitions) and items used in the survey articles (a total of seventy-three unique items) resulted in a categorization into three main categories:

- An organizational category concerning culture and strategy.
- A customer information category, with generation and dissemination.
- A behavioral category in terms of responsive or proactive actions.

This prism of categories is used to analyze the relationship between SCI and CO. The analysis is based on the articles from the search, complemented by seminal articles identified through a search sample snowball approach, or through previous knowledge by the authors.

3 Supply Chain Integration

Supply chain integration studies have found positive effects of customer integration (e.g., Beheshti et al., 2014; Shi and Yu, 2013), and logistics integration with suppliers and customers is related to increased performance (e.g., Prajogo and Olhager, 2012).

Integration and collaboration are used almost interchangeably as terms in literature, but one distinction between them is that collaboration appears to indicate a higher degree of integration. Supply chain integration has been defined as “comprehensive collaboration among supply chain network members in strategic, tactical and operational decision-making” (Bagchi et al. 2005), or as “the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes” (Flynn et al, 2010). These citations illustrate the importance of reaching a high degree of integration in the supply chain. They also demonstrate that integration and collaboration can be interpreted in different ways, depending on the context and study object.

Chen et al. (2009) state that a firm’s strategic priorities should be key factors of supply chain process integration, with the most influential antecedents of supply chain process integration being cost orientation and customer orientation. Zacharia et al. (2009) describe an intense collaboration, or a high level of collaboration, between firms as “the willingness to make decisions jointly, meet often, adopt new ways of doing things, and set common goals for the collaboration effort, all of which require an open exchange of information and ideas.” The sharing of information is a common theme in SC collaboration, emphasized by e.g., Fawcett et al. (2008). Thus, integration and collaboration are of strategic importance and should be grounded in strategy, and at the same time they have an operational dimension concerning daily logistics activities.

Being a driver of increased performance and having an impact throughout the firm’s strategy and operations, SCI is a core concept in SCM. Nevertheless, the arguments for its relations to customer orientation are predominantly proposed on an overall and aggregated level, which is why there is a need to further explore the connections between SCI and CO.

4 Customer Orientation – Categorization of items

The definitions and survey items from the selected articles were analyzed, resulting in three categories of customer orientation (with sub-categories). The categories have a logical sequence of establishing a customer orientation as culture or strategy, generate and disseminate customer information, and the behavior when acting on information.

The organizational category – strategy and culture

The discussion of how to distinguish between strategy and culture goes way back in time. Strategy and culture have been considered either synonymous or as one of them leading to the other. Customer orientation as a strategy could be contrasted with other strategies, e.g., being production-oriented, product-oriented, or innovation-oriented. Lado et al. (2011) argue that SCM requires a fundamental shift in orientation from an internal, production-oriented mindset to an external, customer-oriented mindset. This indicates that customer orientation can be seen as a strategy, guiding the direction of the firm.

Lado et al. (2011) also address the mindset of the decision maker. This is similar to Grawe et al. (2009), who note that a critical component of customer orientation is the emphasis on seeing supply chain opportunities and constraints from the perspective of the customer. These sources support that CO can also be part of the culture of a company, in how the employees instinctively think and react outside set rules and policies as well.

Frasquet et al. (2008) claim that the greater a company’s customer orientation, the greater the trust in the supplier. This is reflected by survey item in the selected articles concerning customer orientation as means of competitiveness. Satisfying customer needs is the primary competitive advantage, a strive to be more customer-focused than competitors. Other items regard goals, visions and strategies related to customer satisfaction and customer needs.

Fantazy et al. (2009) state that “The essences of customer-oriented strategy firms are a search for ways to create close relationships with their customers, providing them with a variety of products and services after sales” This clearly underlines the relationships between customer orientation, strategy, and external integration. The authors take a stance in customer-oriented strategy being a part of the overarching supply chain strategy.

The Customer information category – generation and dissemination

The sub-categories of customer information are generation and dissemination. Information can be generated with or without the customer's active participation. Survey items describing generation of information involve listening to and understanding the customer. Additional items are monitoring and measuring customer satisfaction, in terms of being systematical/ routinized, frequent, and using common measurements. Thus, there is a distinction in the items between customer-oriented measurements and information for the purpose of a deeper understanding of the customer and its processes and tactics.

The emphasis on dissemination in traditional marketing-related customer orientation literature is the internal information dissemination, relating to whom to communicate the results with. Frاسquet et al. (2008) explain how customer orientation cannot be limited to processing information on customers' needs but requires inter-functional mechanisms which impregnate that information into the organization and translate it into specific actions.

The survey items of dissemination of data includes dissemination at different levels in a firm and across units and business functions. Thus, the items mainly suggest an internal perspective, as opposed to sharing information between firms in the supply chain. Moreover, only scarcely addressed among the items in the selected articles is how information is turned into knowledge and learning, e.g., in terms of analyzing the information and the shared interpretation of information. Flint et al (2011) though, explain how "logistics innovation might emerge from processes aimed at gathering deep insights about customers through interactions with customers, interpreting those insights through a process of information sharing and dissemination, and continuously contemplating what has been learned as well as the learning process itself". In sum, the further use of the generated and disseminated information is acknowledged, although not addressed in detail in the selected articles. In the wider SCM literature, Fugate et al. (2008) stress that the obtained data/information has to be interpreted, turned into knowledge, to understand the customer to decide on a suitable response.

Furthermore, the selected articles rarely distinguish between tacit and explicit information. Customer orientation literature focuses on understanding the customer(s), but a source of confusion is what has to be generated from the customer to enable a deeper understanding compared to being responsive to customer-oriented measures.

The behavioral category – responsive and proactive actions

The third category concerns how to behave when having generated and disseminated the customer information. Two alternative actions are suggested, responsiveness to expressed customer needs and proactiveness to meet customers' latent and future needs.

The responsive items contain ways of helping the customer, by responsiveness to customer needs and interaction with the customer, responding to customer complaints, solve delivery problems and speed up deliveries, ability to meet customer expectations, etc. This external interaction is a strive to find customer wants and needs, getting closer to customers in general or more specifically by having regular meetings with the customers.

Proactive items include items of seeking ways to improve products and services (beyond expressed needs), increasing benefits or reduce costs to the customers, or helping customers to acquire information. These proactive items show quite different scopes, either continuous improvement efforts in terms of costs and processes, or in terms of being proactive to future needs (longer term).

While the responsive actions are both integrative and based on active information generation, they clearly relate to the present situation and improvements of the current business offer, the proactive actions typically relate to more strategic considerations and innovative ways of improving customer relations.

5 Discussion

To explain the categorization of CO categories and their relations to customer integration (the type of SCI studied here), a matrix consisting of the degree of CO and customer integration respectively is used for the discussion (to the right in figure 2). We discuss four different paths in the matrix, from different points where there is an increase in the degree of either CO or customer integration. The categories of CO impact the degree of customer integration and how it relates to customer integration.

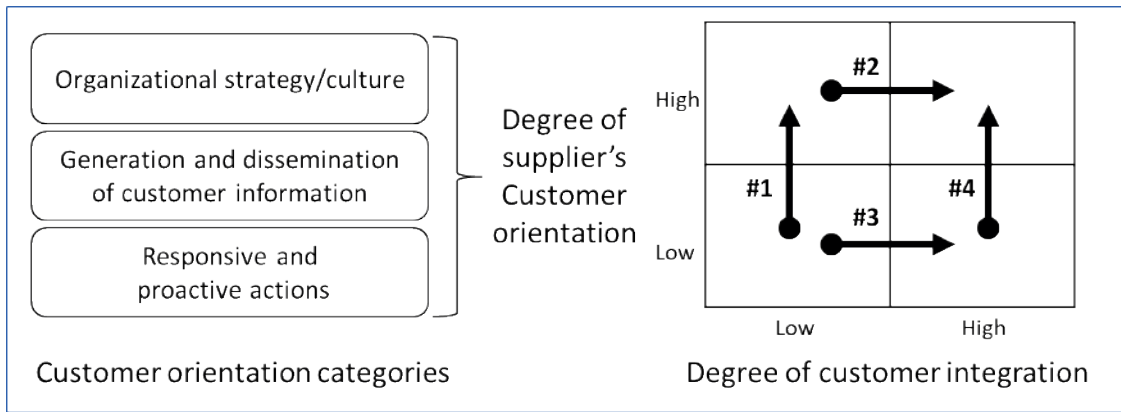


Figure 2. The framework for customer orientation and its categories and their relations with customer integration.

Path #1 From low degrees of CO and customer integration to a high degree of CO

A multitude of findings in the selected articles suggest positive effect of CO, from responsiveness (e.g., Fantazy et al, 2009; Beitelspacher et al, 2012;) to proactiveness (e.g. Grawe et al, 2009; Hallikas and Lintukangas, 2016). Several prerequisites to customer orientation are suggested in the selected articles, e.g., building on culture or strategy, a systems' and learning orientation (Hult et al, 2000) and customer oriented supply chain practices (Jeong and Hong, 2007).

The trigger for a firm to increase its customer orientation could originate from other firms' experiences, or as the outcome from the firm's effective use of customer information, although possibly with limited information and with only local action taken. In essence, even without customer integration, but with a high degree of CO positive effects could be generated, with the main triggers for increasing CO among the organizational and behavioral categories.

Path #2 From a high degree of CO and a low degree of customer integration to a high degree of customer integration

When having a high degree of CO, a natural step is to increase the degree of customer integration. Hofer et al. (2014) claim that a customer-oriented firm recognizes that its strategic approach to achieving performance goals requires collaborating with its customer and must be willing to learn about the customer's organization. Fantazy et al. (2009) state that the essences of customer-oriented strategy firms is a search for ways to create close relationships with their customers. Nahm et al. (2004) found that high levels of customer orientation led to a set of managerial beliefs that are collaborative and integrative. The findings of Yunus and Tadisina (2016) show that firms' customer orientation (CO) triggered the initiation of SCI.

Customer orientation can be considered as a stage preceding integration. If externally integrated, the firm has the option to capture additional data because of its CO and even discuss with the customer what information that preferably would be shared. When integrated the supplier has the opportunity to gain not only explicit knowledge but also tacit knowledge, which in turn could result in a better understanding and more proactive actions. Path #2 therefore relates clearly to all three CO categories.

Path #3 and #4 From low degrees of CO and customer integration to firstly a high degree of integration and then secondly to a high degree of CO

Integration between a supplier and a customer is possible without the supplier having a customer orientation. A customer could more or less force a supplier towards and into integration. A supplier with no or low-level of CO may not even consider the extended use of information or have difficulties in understanding customer processes. Such integration (Path #3) could e.g., focus on electronic integration for automation of transactional data (rather than organization integration) or the customer requiring the supplier to be part of a vendor managed inventory program.

Once integrated, the supplier would understand the benefits of extended customer information and gain the similar benefits as the endpoint of Path #2. The research by Beitelspacher et al. (2012) indicates that organizations who choose key channel

partners with whom they have high-quality relationships, are more likely to develop a successful service culture and CO. Moreover, Yunus and Tadisina (2016) found that “Firms’ customer orientation (CO), will be positively related to the degree of SCI”. As the level of firms’ CO increases, the need to satisfy their customers increases as well, and as a result, firms attempt to achieve this satisfaction by collaborating internally and working closely together with their supply chain partners. Paths #3 and #4 are related to all the three categories of CO which together provide explanations for these paths.

6 Conclusions

The paper set out to build a conceptual framework based on categories of customer orientation, and further to explore the relations between customer orientation (CO) and supply chain integration (SCI). Based on a literature review and analysis three main categories were developed: i) An organizational category concerning culture and strategy; ii) A customer information category, with generation and dissemination; and iii) A behavioral category in terms of responsive or proactive actions. The framework was useful when analyzing the connections between CO and SCI, and a deeper understanding was developed for how CO and SCI respectively can develop, and their synergetic relationship. Thereby, this paper contributes to deepening the understanding of the relation between CO and SCI from both a managerial and theoretical perspective, with CO being a joint marketing-logistics concept.

One limitation of this research is the focus on one of many similar concepts for capturing customer orientation in supply chains. An expansion of the research would be to include more concepts used in literature, and thereby further deepening the understanding and developing the framework into possibly more categories. Another suggestion for future research is to apply the framework in empirical research to test its viability in a practical setting and to further operationalize the categories. The framework can also be adapted to help practitioners analyze their own supply chain context and provide guidance for how to address an urge to increase their firm’s customer orientation and consider the benefits of supply chain integration.

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A SIMULATION STUDY TO UNDERSTAND ENERGY USAGE REQUIREMENTS OF ELECTRIC BUS FLEETS

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1. Introduction

In recent decades, a significant interest towards electrified vehicle propulsion has been observed (Reiner et al., 2020). This has been aided in particular by the policies promoting e-mobility adopted by government bodies throughout the world, particularly in the UK (Department for Transport, 2018), the EU (European Commission, 2021), and the US (US EPA, 2022). The mass adoption of electric propulsion in the automotive field, alongside recent technological progress in power electronics and battery technology, is bound to bring significant decreases in vehicle lifetime carbon dioxide emissions.

However, a large share of the current greenhouse gas emissions attributed to the transport sector, especially in urban areas, is comprised of tailpipe emissions produced by public transportation methods, such as Diesel-powered buses (European Commission, 2020). Although in recent years, several electric motor-based alternatives to ICE buses have been presented to the market, there are still some concerns regarding the feasibility of employing eBus fleets. This is likely due to the high degree of diversity observed in urban areas worldwide, ranging from differences in topography to population density and distribution. Additionally, electric vehicles still present increased system mass relative to their ICE counterparts, at the of increased energy consumption. The objective of this paper is to provide more data to the scientific community and hopefully further clarify the efficacy of electric bus fleets in terms of energy usage.

This paper presents a novel investigation that employs both artificially made bus telemetry and real-life vehicle data, including elevation, speed and distance readings, in order to better determine the energy consumption figures of electric buses. The artificial routes are constructed mathematically through using average speeds for these vehicles and observed acceleration intensities. Additionally, the analysis relies on energy usage predictions produced by a state-of-the-art vehicle software model, as well as common mathematical methods to generate artificial vehicle telemetry. To provide a more enhanced perspective, the analysis also utilises real-life telemetry data that has been recorded through GPS loggers. The simulated energy consumption figures will then be compared to determine the accuracy of the method used to generate vehicle data telemetry through comparing the energy usage results. The originality of this research lies with the methods and tools used for the analysis, which are novel in the fields of mathematical simulations, as well as introducing new, novel energy consumption figures for electric buses to the scientific community. Similarly, the presented analysis is based on a blended approach involving mathematical simulation, as well as logistics management. Finally, it will showcase an overview of the expected energy consumption and range performance metrics of current electric bus vehicle concepts as well as indications as to how these could be improved.

2. Research Background

In order to better grasp the benefits of implementing an electric bus, the primary limiting factors of an electric vehicle must be understood. Previous research has identified a range of subsystems that significantly increase EV energy consumption, such as the electric motor efficiency, and aerodynamic resistance caused by the frontal shape and area of the vehicle. However, the main factor that influences vehicle energy consumption is represented by the energy storage system weight, which is conversely decided by system energy storage density. For electric vehicles, all these factors are closely interconnected with battery sizing. In order to improve the energy storage system capability, and therefore extend vehicle range performance, there are several potential research aspects may be considered.

Firstly, research concerning optimised battery designs has gained significant interest in recent years. These new designs aim to increase energy storage performance figures by employing novel material technologies (Blomgren, 2017). Besides the conventional technologies available nowadays, such as lead-acid and Li-Ion, there has been plenty of research carried out into promising novel materials that are able to store significantly higher energy capacities, such as Li-Air, Li-Sulphur

and solid-state batteries (Manzetti and Mariasiu, 2015). Some of these concepts have matured up to the level of being production-ready and preliminary figures suggest an increase of up to 16% in effective range for the vehicles employing novel battery materials (Business Insider, 2019). Additionally, the recent unveiling of market-ready energy storage systems featuring solid-state batteries may provide significant performance leaps in terms of energy storage capacity and conversely vehicle range (Toyota, 2023).

Secondly, there are several concerns concerning the efficacy of employing high-power electric vehicle charging for heavyweight electric powertrains (Lamonaca and Ryan, 2021). Whilst the decreased charging times are quite a big step forward in terms of electric vehicle fleet usability, recent research indicates that battery charging at high power ratings may cause battery pack “charging stress” that results in decreased battery lifetime, which translates to decreased vehicle range. Conversely, this quick decrease in the battery’s state of health will lead to shortened vehicle lifecycles, decreasing the vehicle lifetime and rendering EVs uncompetitive when compared to their ICE counterparts. The accelerated decrease in battery lifetime due to high-power charging can be partially mitigated by employing “smart charging” techniques. These consist of employing scheduled battery charges at set power ratings, but also reductions in charging power if the state of charge of the battery crosses a certain threshold (Lu et al., 2018). However, the full mitigation impact of such strategies on the battery lifetime remains to be fully understood.

Finally, another potential solution to the problem of EV energy recharge and vehicle range may be offered through the battery swapping concept. The concept has been previously looked into with early passenger electric vehicle designs (Sarker, Pandžić and Ortega-Vazquez, 2013); however, it did not gain significant industry popularity, potentially due to the high incurring infrastructure costs.

3. Methodology

In order to determine the simulated energy usage through utilising the abovementioned vehicle software model, datasets comprised of speed-time or speed-distance pair values are required. This type of data, also known as telemetry, may then be used as input for simulation through the proposed model.

As previously stated, two approaches for acquiring vehicle telemetry have been considered. Firstly, an approach consisting in generating artificial telemetry through observing driving behaviour has been developed. A further method that involves acquiring real-life telemetry data has then been created.

3.1. Generating Artificial Vehicle Telemetry

The bus routes that have been chosen for the analysis are real routes that are currently being served by both conventional diesel-powered and hybrid buses, and operate around the Sheffield, UK city area. The distances covered by these routes are relatively short – however, their operating profiles vary, in order to accommodate a diverse set of routes. After defining the route dataset, the speed-distance values which constitute the artificial telemetry have been generated based on the distance between bus stops along the routes.

The proposed simulated telemetry is based on trapezoidal approximations. Conversely, the speed-distance dataset describes trapeziums (i.e., speed increase – constant speed cruise – speed decrease) between each stop. The increases and decreases in speed have been calculated such that they are the equivalent to the bus driver employing up to 50-75% of the vehicle’s acceleration and deceleration performance. The acceleration is maintained at that level until the average maximum bus speed limit is reached. This behaviour that has consistently been observed throughout several bus routes with different bus drivers, therefore it is expected to reflect real-life driving scenarios with reasonable accuracy. The constant speed cruise value has been set to be the bus average speed observed in urban areas.

An example of one of the chosen bus routes, along with the produced simulated telemetry can be observed in figure 1. The simulation results of the simulated dataset will be presented under section 4, alongside the real-life telemetry ones.

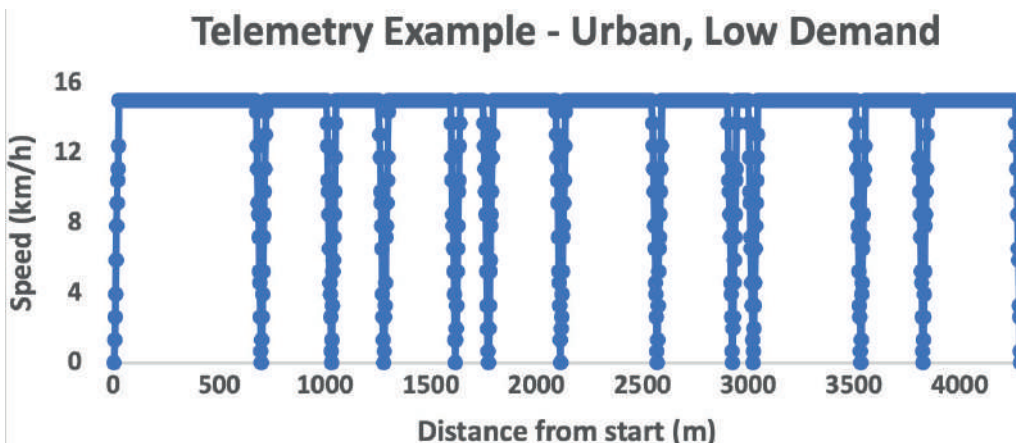
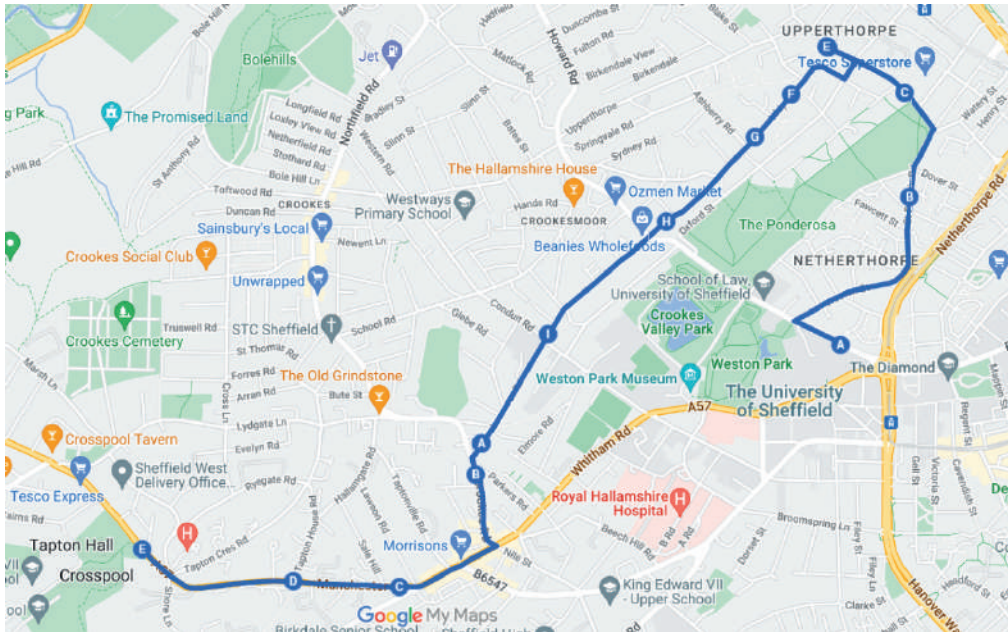


Figure 1: Example of bus route and its simulated telemetry.

3.2. Acquiring Real-Life Telemetry Data

As previously mentioned, the approach presented in section 3.1 has been further consolidated through employing real-life bus telemetry data. This section outlines the method used for acquiring this dataset. The real-life dataset is expected to further improve the predictions offered by the artificial telemetry approach and improve the energy consumption simulation accuracy.

In order to provide a good baseline comparison with the artificially generated datasets, the telemetry of buses driving on several bus routes with similar demand and urban/rural profile features have been chosen for data acquisition. Each of the chosen routes feature telemetry for full, return journeys. An example of recorded telemetry, as well as the mapped routed upon which it was recorded can be observed under figure 2 below.

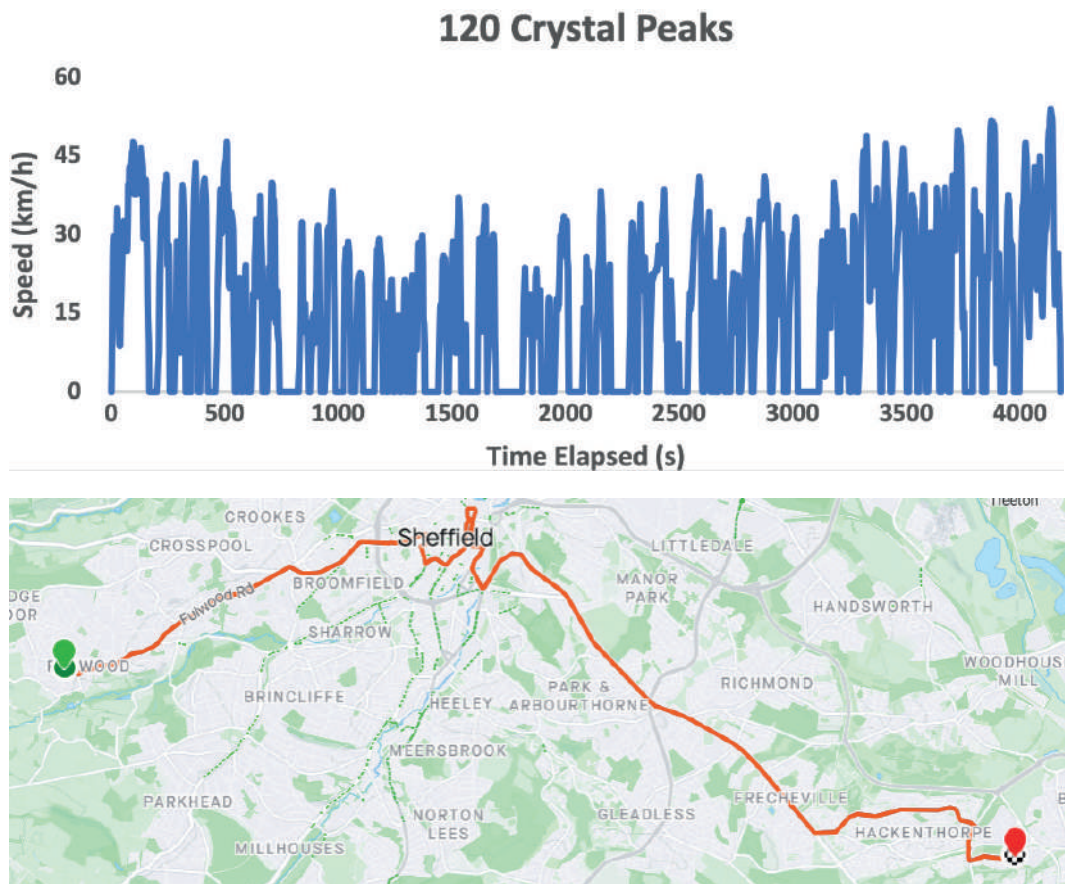


Figure 2: Example of recorded real-life bus telemetry

As opposed to the artificially generated telemetry, the method employed for recording this data produces speed-time key value pairs. However, the methodology is similar, as these are then manipulated by the vehicle model and utilised as reference data for the model control system. In order to ensure input dataset reliability, two methods of obtaining the final input telemetry data have been used.

Firstly, the speed-time value pairs may be obtained through time-based logs present in global positioning system (GPS) datasets ('Global Positioning System Standard & Positioning Service Performance Standard 4th Edition', 2008). These usually consist of entries of value sets comprised by recording time, latitude, and longitude. The data resolution, which is usually linked with the sampling rate at which GPS data is being recorded, is normally bounded to time. For the purposes of this investigation, a data resolution of 1s has been utilised.

The time-based GPS data has been recorded using two different devices. Firstly, a Garmin eTrex 10 GPS logger (Garmin eTrex® 10 | Outdoor GPS, 2023) has been employed for data acquisition, which has been set to have a sampling rate recording of 1s. Additionally, in order to ensure the reliability of the data acquisition process, the GPS-based vehicle telemetry has also been recorded through utilising the mobile-supported Strava app (Strava, 2023). The software, which has gained significant popularity with runners and cyclists thanks to its ease of use, employs the smartphone's GPS sensor upon which it was installed for acquiring GPS information. Finally, both solutions used for recording GPS-based telemetry are able to output the recorded information as files encoded using the open-source GPX format. These have then been converted to CSV files using the Garmin BaseCamp (Download BaseCamp | Garmin, 2023) software.

After the GPX to CSV file conversion, the distance between the geographical coordinates in the log entries is calculated in order to obtain speed-time value pairs. However, linear mathematic equation sets are unsuitable for calculating distance in a spherical surface (i.e., the Earth's surface). This is due to the reference of the latitude/longitude values, which are tied to a sphere's surface rather than a flat plane. Therefore, in order to determine the direct (i.e., as the crow flies) distance between two coordinate-described points, a mathematical conversion of distance from spherical to flat spaces must be used. To this end, there are several methods which may be used, however, the Haversine formula (Van Brummelen, 2012) has been

employed, due to its high conversion accuracy, as described in equation set 1 below, with λ values being the latitudes and R values the longitudes of the entries in radians (1,2 denoting which is the origin and destination point), is the Earth's radius in metres, d is the final linear distance in metres and a and c being annotations to simplify the displayed equation set.

$$a = \sin^2 \frac{\Delta \varphi}{2} + \cos \varphi_1 * \cos \varphi_2 * \sin^2 \frac{\Delta \lambda}{2}$$

$$c = 2 * \arctan(\sqrt{a}, \sqrt{1-a})$$

$$d = R * c$$

Equation 1 (set) - Spherical (Great Circle) to linear distance conversion using the Haversine formula

Following the distance conversion, the speed is then effectively the distance between the point entries. Finally, a conversion from m/s to km/h is carried out by applying the 3.6 constant to all values (1 m/s = 3.6 km/h). An example of telemetry section generated employing this method can be viewed under figure 3.

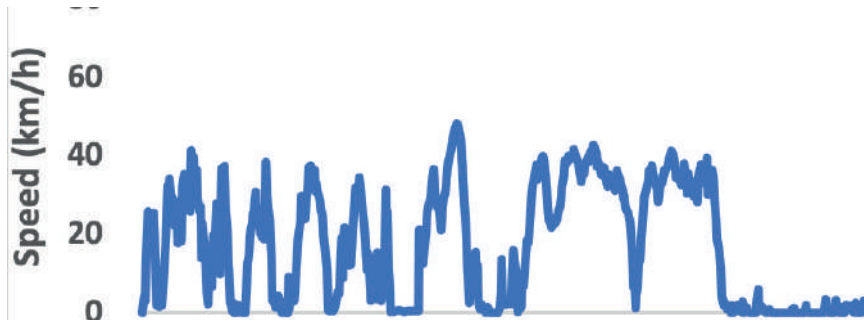


Figure 3: Example of telemetry produced using GPS data and the Haversine conversion.

The second method used for recording real-life telemetry data is also based on information logged by the mobile-supported Strava app. The advantage of this recording method is that it convolutes location-based information with readings logged by the mobile phone's integrated accelerometer. This has a beneficial effect on the recorded telemetry accuracy, as it eliminates positional inaccuracies in the GPS readings due to bad signal.

In order to acquire the Strava app enhanced speed data readings, the information is exported as Strava's proprietary format, FIT files. These are then parsed using the FitParse Python library (GitHub - dtcooper/python-fitparse: Python library to parse ANT/Garmin .FIT files, 2023), which decodes the format. The speed-related information is then extracted and written in a CSV file. An example of a telemetry portion generated using this method can be observed under figure 4.

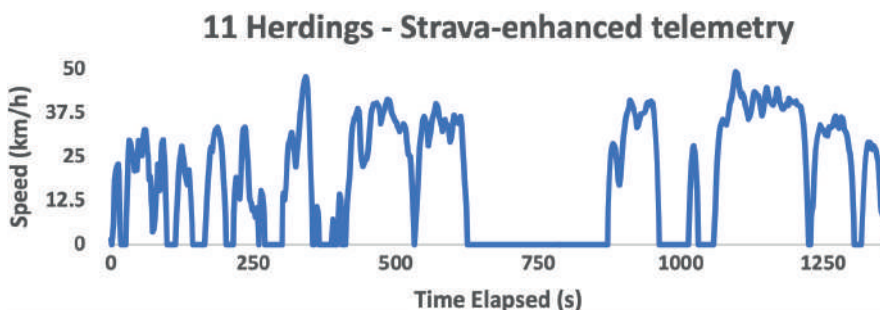


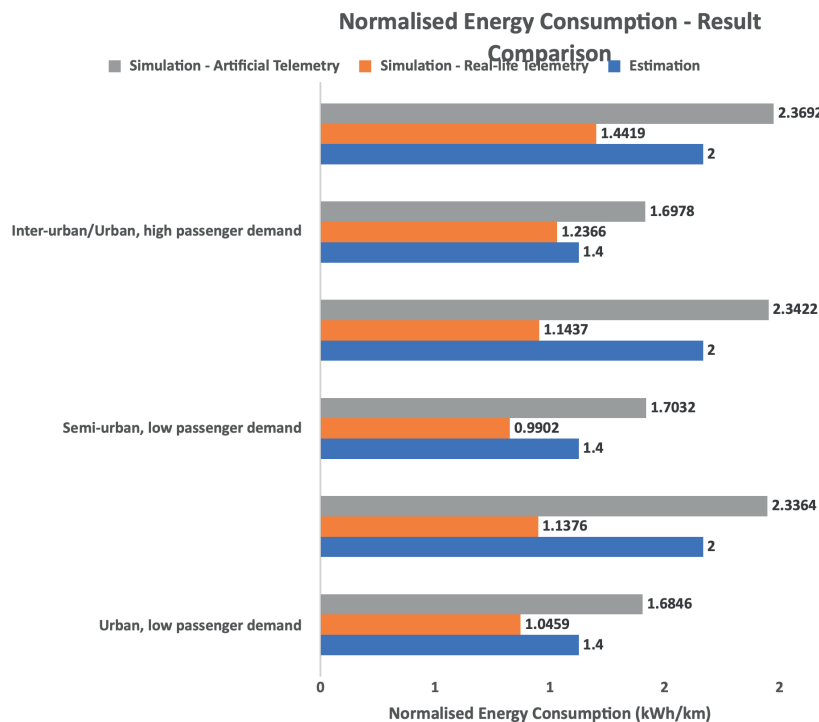
Figure 4: Example of telemetry produced using Strava's proprietary enhanced speed calculation method. Note the vehicle idling periods set to zero and the "cleaner" telemetry aspect in general, relative to figure 3.

4. Simulation Results

As previously mentioned, bus routes having similar features were chosen for comparison in order to ensure a consistency. Figure 5 below shows the energy usage prediction for 3 different route profiles. The values are expressed as a distance-normalised energy consumption, as the covered distance between the routes varies. The estimated consumption using a widely-used literature figure (Vilppo and Markkula, 2015) is also displayed, for reference.

It can be observed (figure 5) that although the real-life telemetry energy consumption is predicted to be smaller than the initial simulations based on artificial telemetry, the variation appears consistent throughout the routes and bus types. Moreover, the smaller consumption may be attributed to several factors, for example the driving style. The artificial telemetry data describe frequent, aggressive accelerations and decelerations, whereas the real-life data has portions of slow-steady deceleration through motor braking, allowing the bus to recover some vehicle inertia-bound energy as electricity.

Moreover, the frequency of stops in real-life situations appears to be significantly when compared to the artificially produced datasets. This conversely leads to less start-stop cycles, effectively leading to steady driving for longer periods of time, which is less wasteful in terms of energy consumption. Furthermore, the recorded routes have been predominantly logged during off-peak traffic hours (before 9am and past 6pm). Therefore, energy consumption during peak times will likely be significantly higher.



5. Conclusions

The conclusions suggested by the recorded and artificial telemetry data further back up the argument currently made in recent literature regarding the feasibility of electric bus fleets in urban, semi-urban and inter-urban environments. This states eBus technology has the potential to be significantly greener than conventional ICE solutions, whilst also being more economical in the long run. Additionally, the presented energy consumption figures may be further used as a basis to produce more detailed analyses towards how and whether the energy grid infrastructure capacity should be upgraded. Similarly, investigations concerning the feasibility of using electric bus fleets as energy grid support during peak hours should be determined.

The data gathered as part of this investigations, along with the previously presented results aim to positively contribute to maximising transport efficiency, whilst also enabling electric buses to be adapted to the current existing logistic models at minimal additional expense, energy grid stress and productivity disruption. Conversely, implementing an electric bus fleet which also provides considerations towards sustainability constitutes a way forward for decarbonising public transport in a way that is financially in the current business context.

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SUPPLY CHAIN DESIGN THROUGH DESIGN THINKING AND 3D CONCURRENT ENGINEERING

Fares Sweeney

Abstract

Purpose: The purpose of this paper is to explore the design of current and new supply chains through design thinking and three-dimensional concurrent engineering.

Research approach: An empirical study has been conducted with experts. Survey investigation for collecting data has been performed.

Findings: Some key parameters to be considered when designing supply chains have been identified. In addition, some enablers of design thinking and concurrent engineering to designing supply chains have been explored.

Research impact: For scholars, this paper contributes to the body of knowledge of supply chain by pinpointing the opportunity of critical thinking toward better interactions among supply chain operations.

Practical Impact: This study enables supply chain managers to more efficiently structure the supply chain networks. This would enable them to move across the knowledge stages from sellers-buyers tiers to a holistic knowledge exploitation.

Introduction

Connection between all supply chain (SC) entities at both upstream and downstream sides are key to strategic success. Precisely, following the Covid-19 pandemic (Fares & Lloret, 2023; Fares & Lloret, 2022; Fares et al., 2022) be it retailer, manufacturer or supplier, each supply chain actor aims to plan the future handling of demand to a high level of accuracy. Forecast errors not only impact the organisation's performance but the robustness of the whole supply chain. Accumulating these errors within the supply network end up by the bullwhip effect (Wang & Disney 2016).

The problem here is that modern supply chains are even more complicated than the traditional ones given the real time data management and the data driven organisations (Sundarakani et al., 2021). In addition, the emerging challenges including disruption risks and vulnerability have created a disturbance affect among supply chain networks (Ivanov et al., 2019). Therefore, our motivation here is to investigate a proactive mode of supply chain design that could decrease the ripple effect among supply chain tiers.

In this paper, we aim to conduct a preliminary analysis of the supply chain design. We seek to check if it is worth redesigning the current supply chain and how collective knowledge can be invested to design new supply chains. Furthermore, we seek to know if design thinking and concurrent engineering could be enablers of an efficient design. The remainder of the paper is organised as follows: Section 2 outlines the theoretical background and the literature review, Section 3 describes the methodology used, and Section 4 presents and discusses the findings. Finally, Section 5 presents concluding remarks and implications.

2. Theoretical background and literature review

2.1 Supply chain design

Supply chain design has been stimulating the research interests among both academics and practitioners. The main drivers behind this motivation are due to the shrinking resources of manufacturing bases, rising manufacturing costs, shortened product life cycles, and globalisation of market economies of the playing field within manufacturing (Beamon, 1998).

According to Chopra & Meindl (2001) and Meixell & Gargeya (2005) a supply chain design problem includes decisions associated with the:

- Supplier selection for sub-assemblies;
- Components and materials;
- The number and location of production facilities;
- The assignment of each market region;
- The capacity of each facility.

Therefore, an optimally designed supply chain must reflect the best operation and configuration through one or more metrics of facility transportation, supply, manufacture, storage, processing facilities, factories, trucks, trains, sea-faring vessels, and warehouses (Garcia & You, 2015).

2.2. Design thinking

Design thinking is defined as a creative and analytic process that involves opportunities of experiment, getting feedback, creating prototypes, and redesigning (Razzouk, R. & Shute, V., 2012). According to Moseley et al. (2018), the definition of design thinking has shifted over the past decade from 'the interior situational logic and decision-making processes of designers in action' toward a highly understood concept for non-designers to assess problems. Hence, design thinking tools have been used for creating value and innovation in several sectors including primary school education, medicine, law, business and science (Pande & Bharathi, 2020).

2.3 Concurrent engineering

The concurrent engineering method has been pivotal to product development over the last several years. It is defined as a systematic design approach enabling items to be produced in a shorter time, with lower prices, and higher quality by integrating the concurrent design of the item with the related quality (Sapuan & Mansor, 2014). According to Tang et al. (2000), the former sequential design process has been recognised as inefficient as it causes grater costs, lower design quality, and greater lead times. Hence, concurrent engineering considers design concerns simultaneously instead of consequently. In practice, Koufteros et al. (2021) confirm that this method enables quick and effective information flow among the organisation by reducing uncertainty and endorsing debate environment. As a result, the related organisational practices have a huge effect on premium price capabilities, quality, and product innovation.

2.3 Theoretical grounded motivation and research questions

Given the complexity of the multiple distribution, supply, and production facilities, Garcia & You (2015) emphasised the great economic potential to optimally coordinate and design supply chain entities. This design would involve all entities in large scale operations under uncertainty. Hence the research questions of this study are as follows:

1. What are the drivers and key parameters to consider when designing a new SC?
2. How can design thinking and 3D concurrent engineering help in designing a SC?

To answer these questions, an exploratory empirical study has been conducted.

3. Methodology

In order to proceed with the data collection, a survey was conducted with six experts (Table 1) . The survey consisted of the following questions:

- What are the key parameters to consider when designing a new SC?
- Do you think current SCs should be re-designed? Please explain why.
- In your opinion, how can design thinking help in designing a SC?
- In your opinion, how can 3D concurrent engineering help in designing a SC?

Table 1. Experts 'profiles

Expert	Position	Department	Total years of experience
1	Professor	Industrial Engineering	21
2	Associate Professor	Industrial Engineering	25
3	Professor and researcher	Industrial Engineering	15
4	Professor	Industrial Engineering	14
5	Professor	School of Management	35
6	Owner-manager	-	15

The survey link was shared online. The research background and context were shared with all the participants. Furthermore, respondents were assured about maintaining their identity through a confidentiality statement following empirical research ethics. Therefore, only a description of the experts' profiles are outlined.

4. Results and discussion

In the following sections, we outline the main findings of the empirical investigation. Raw data has been analysed and insightful contributions have been depicted and discussed in the context of the current literature.

4.1 Drivers to redesign current supply chains

All respondents confirmed the necessity of redesigning current supply chains. The related drivers are described as follows:

- Supply chain re-design involves complex competencies such as integration with suppliers and customers to create value as well as the acquisition of external information and its transformation into practices capable of producing marketable outputs. These competencies are contextually specific. Similarly, Graham & Hardaker (2000) emphasised that the concepts of supply-chain design and management have become more important because of the increased complexity of the systems driving buyer supplier relations.
- Most of the current supply chains do not take into account sustainability and resilience. It has been argued that creating resilient SC network designs can enable the survival of SCs and markets through disruptions like the Covid-19 pandemic (Aldrighetti et al., 2021).
- Current supply chains should always be in line with the changes following new logistics master plans. In fact, challenges of global trade, customer expectations, and legislations

are continuously changed. Therefore, supply chains should be in line with these changes in terms of design, management, and planning (Allaoui et al., 2019).

- Whenever there is a need for a step-change in performance such as delivery delays and forecast errors. In fact, supply chain design must reflect the market and business priorities and respond effectively to those requirements along the whole spectrum of upside and downside outcomes (Samson & Gloet, 2018).

4.2 Factors impacting the design of new supply chains

- Logistics costs including inventory holding costs. This is confirmed by Bottani, E. & Montanari (2009). The authors outlined that total logistics costs are affected by supply chain design parameters such as the number of echelons, re-order and inventory management policies, demand information sharing, and responsiveness of supply chain players.
- Sustainability and flexibility. In fact, the resilience of a supply chain is highly correlated with its structure and design since firms with efficiently designed supply chains are more likely resilient to disruption risks (Jabbarzadeh et al., 2018).

- Product range and logistics stakeholders. This joins the arguments of Appelqvist et al. (2004). The authors pointed out that new products must be designed in such a manner that they allow good demand-supply chain performance which must have already been explicitly analysed in the concept design phase of new product development.
- Digitalisation. It has been argued that industry 4.0 drove firms to adapt to the emerging disruptive technologies by reconsidering their supply chain design (Aamer et al., 2022)
- Matching resources with demand and understanding customer requirements sets the specification for the SC. In this context, Collin et al. (2009) discussed three design concepts that guide supply-demand matching. The first one is demand viability which is the point in the demand chain where the customer's demand is allocated to a specific supplier. The second, is the order penetration point which impacts customer satisfaction. The final point is the customer value threshold which demonstrates the performance level in customer operations.

4.3 Enablers of design thinking to supply chain design

- Design thinking is generally undertaken to solve a problem or optimise a design. In current literature supply chain design has been used for various optimisation purposes. For instance, Huang, Y. L. & Huang, D. H. (2020) used design thinking to optimise change management procedures. The authors found that integrating design thinking and change management can enable physical bookstore owners to efficiently define the visions of their firms when they are managing the change.
- This will certainly be beneficial in speeding up the process and designing a SC that takes into account the constraints of all stakeholders. In fact, it has been argued that design thinking has been applied in the context of supply chains to bring in an innovative, new, human-centred design to supply chains (Banerjee & Mukhopadhyay, 2016).
- Creative thinking can always contribute to SC design. Creative supply chain solutions became essential during the Covid-19 pandemic. This provides evidence that people with creative personalities are more likely to identify and pursue new business opportunities (Ketchen & Craighead, 2020).

4.4 Enablers of 3D concurrent engineering to supply chain design

- 3D Concurrent engineering is a powerful enabler in supply chain management since it is important to involve suppliers in the early stages of design. Siemieniuch & Sinclair (2000) discussed the following assumption that if the supply chain is required to have a specific behaviour from a concurrent engineering point of view (such as quick decision-making, flexibility, and high quality), then the jobs supply chain practitioners must be constructed such that this behaviour will come about.
- 3D concurrent engineering or the integration of all functions at the design stage, allows the design of a SC perfectly adapted to the needs of the company and its strategy. In this context, Ellram et al. (2007) emphasised that 3D concurrent engineering presumes that products and processes must be designed simultaneously, involving multi-functional teams early in the process, which could include customers and suppliers.
- Concurrent engineering can enable a multi-disciplinary team to contribute to the design of a SC which reduces the design failure risks. Anumba et al. (2020) focussed on the implications of a concurrent engineering environment for supply chains and pointed out that concurrent engineering is a critical approach in any construction process, enabling time and cost reductions and organisational efficiencies.

5. Conclusion

The main goal of this research was to have an exploratory investigation regarding supply chain design and how concurrent engineering and design thinking could enable it. Our findings reveal that resilience is among the main drivers of supply chain re-design while logistics costs and matching supply-demand highly impact new supply chain design. On the other hand, design thinking can ensure taking all the stakeholders' constraints while concurrent engineering can ensure a multi-disciplinary integration.

Even if experts outlined the importance of 3D concurrent engineering, most of literature arguments focus on regular concurrent engineering for supply chains rather than the 3D aspect. For instance, Bakås et al. (2015) analysed the feasibility of performing supply chain design in 3D concurrent engineering. One of the limitations of this research was that the number of experts was limited to six. Expanding the sample size while ensuring a balance between the academics-practitioners profile could leverage the empirical insights. Future research could focus on specific industrial fields. For example, fast fashion supply chains could be a promising investigation area (Fares & Lebbar, 2019) given the quick responsiveness of this business.

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THE EMERGING ROLE OF AUTOMOTIVE INDUSTRIAL CLUSTERS IN THE TIME OF THE COVID-19 CRISIS

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Introduction

Background

Industrial crisis has been exacerbated by several unpredictable and unexpected events that have had major social, economic and health system disruptions to businesses around the world (Kim et al., 2022). From the Great Depression of the 1930s, the economic recession of the 2000s and Brexit, to the global Covid-19 outbreak and the Russia-Ukraine war, production systems have been put under great stress to mitigate damages, prepare, intervene, and recover their operations, and eventually rebuild society. In such times of crisis and volatility, many automotive clusters have demonstrated a superior capacity to withstand external shocks owing to their close inter-firm collaboration, capital and risk sharing and spatial proximity. In contrast, other clusters have faced a decline due to their failure to transform traditional manufacturing into innovation-based high value production (Bartholomae et al. 2017). The success of each scheme depends on a plethora of factors ranging from their socio-economic roots to the level of agglomeration, technological advancement and economic growth considering their interactions with the academia, businesses and Governments.

Research Gap

An increasing stream of research has highlighted the need for industrial clusters to develop sustainability approaches to combat the challenges arising from disruptive events (Barakat et al., 2023). A few studies (e.g. Kim et al., 2022) have examined how industrial clusters can serve as sources of economic resilience by decreasing operational, logistics and energy costs and minimising resource utilisation. Numerous researchers (e.g. Daddi et al., 2017) have investigated how industrial clusters can mitigate the environmental impacts of their operations, adopt circular economy principles and reduce energy consumption. Only few studies have examined how industrial clusters can affect the welfare of communities and promote equality, social justice and stability in employment (e.g. Nadvi and Barrientos, 2004). Yet, the impact of industrial clusters on social sustainability in turbulent times remains largely unexplored.

Aim and Objectives

This paper investigates the role of industrial clusters in accelerating the recovery of local communities from the socio-economic consequences of the Covid-19 pandemic. Through a review of the theoretical literature and the examination of some of the largest automotive clusters around the world, it explores the pre-existing social conditions that have contributed to their creation and growth and examines how these along with later developments (e.g. national policies, entrepreneurial activities, and interactions with local academic institutions and businesses) have helped them to demonstrate a superior capacity to withstand pandemic shocks, support regional and national response measures and transform into sources of knowledge exchange, social welfare, technological innovation, and economic growth.

Methodology

Analysis initially focuses on the wider manufacturing sector before narrowing down on the automotive sector and the 20 largest automotive industrial clusters around the world (Detroit, Stuttgart, Tokyo, Shanghai, Turin, Chennai, São Paulo, Togliatti, Seoul, Bangkok, Coventry, Graz, Tychy, Guanajuato, Valencia, Bursa, Mladá Boleslav, Ulsan, Gothenburg and Hsinchu). A database with their key characteristics was compiled using published data. To this end, an interpretivism research philosophy using a deductive research approach was adopted to review published information about the selected case studies.

Introducing the Concept of Industrial Clusters

The Origins of Industrial Clusters

The first clusters of businesses operating in related industries and in close proximity can be traced back to ancient times in the form of partnerships between different individuals belonging to common social networks (Dai et al., 2021). These were often the result of unique regional recipes with a short-term perspective that aimed at resolving immediate problems by taking advantage of favourable geographic conditions and locally available natural resources. As a result, most proto-clusters turned out to be low institutional ventures defined by birthplace or ethnicity, whereby a person was trusted on the basis of attributes adhered to particular community norms, and impersonal or family links (Gómez-Galvarriato, 2008). With time, those formations emerged into engines of knowledge application, commercialising discoveries, and developing new industries. The most notable proto-clusters included aggregations of weavers, spinners, dyers and traders in the city of Akhmim in ancient Egypt which hosted one of the most thriving textile industries of the time; partnerships of local craftsmen, suppliers and traders building together ships in the island of Samos in ancient Greece; and craftsmen and artisans concentrating near temples and palaces in ancient Sumeria producing jewellery and artworks. These, however, were high-risk ventures ruled by personal relationships and characterised by slow communication and lack of formal governance. Soon, the first industry associations of bakers and carpenters, were formed in ancient Rome to regulate their affairs, set production standards, and protect their own interests. Known as 'Roman Collegia', these were the first networks of trusted business partners whose aim was to collaborate and exchange knowledge to lessen financial risks and mitigate the impact of external hazards (Buchnea, 2016).

The Genesis of Contemporary Industrial Clusters

The emergence of industrial clusters in their current form has been driven by the first two Industrial Revolutions. These signified a turn to mass production using powered, special-purpose machinery and the accumulation of capital and labour in their surroundings. The English Economist Alfred Marshall examined the causes behind the co-location of textile businesses that flourished in England after the 1st Industrial Revolution (Marshall, 1890). He highlighted the role of geographic conditions and available natural resources in the spatial concentration of same-industry businesses. He explained how business aggregations enable the transmission of skills and knowledge from one generation to the next; encourage the sharing of ideas, constant improvements, and developments; enhance the regional growth of subsidiary supply firms; attract specialised labour; and develop highly specialised machinery to support large aggregate production. He also discussed how clusters enable SMEs to focus on one step of the production process enhancing their specialisation, efficiency and productivity. Furthermore, he discussed how the co-location of businesses enables informal communication and social interactions among employees and employers.

The Evolution of Contemporary Industrial Clusters

Orsenigo (2006) supported that as much as agglomeration forces are affected by structural initial conditions, it is processes that form actual industrial clusters. On this basis, Feldman (2001) claimed that the formation of modern clusters is an endogenous evolutionary process which relies on the extension of the classic product life cycle model describing the key development stages of birth, growth, decline, and regrowth. According to Kim et al. (2022), this conceptualisation considers the impact of both internal and external factors on the way the life of each industrial cluster flows at different lifecycle stages. Feldman and Braunerhjem (2006), for example, recognised that although the emergence of industrial clusters may be the result of triggering external events or pre-existing social and natural conditions, developments in later phases, such as vigorous entrepreneurial activities and the active building of institutions that nurture the agglomeration's own internal functions, are critical elements in paving the way to a sustainable growth trajectory. Pursuing a strategy of profusion and nurturing the flow of tacit knowledge amongst business partners, are essential ingredients for a cluster's success. This also enables new cluster entrants with lower capital size to enjoy a faster growing rate and greater sharing of capital and risks (Dai et al, 2021).

Defining Industrial Clusters

Becattini (2004) defined industrial districts as 'socio-territorial entities characterised by the presence of a community of people and a population of firms in one naturally and historically bounded area with a dominant industrial activity'. His definition is in line with Marshall's (1890) notion that industrial districts form 'concentrations of specialised industries in particular localities'. Michael Porter (1990) used instead the term 'cluster of industries' suggesting that a cluster is composed of 'industries connected through vertical (buyer/supplier) and horizontal (customers, technology, distribution channels) relationships'. Considering geographical proximity and the competitiveness of regions, he updated his definition to 'geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, and trade associations) in particular fields that compete but also cooperate' (Porter, 1998). Similarly, Wilson and Popp (2003) emphasized the need for 'a wider agglomeration of industries to not only 'be connected by common products, technologies, and markets, but also from institutional frameworks'. Yet, more recent definitions, suggest that the concept of industrial clusters goes beyond that of firm networking and captures all forms of knowledge sharing. Martinez-Canas et al. (2021) defined clusters as 'groups and networks of interdependent firms, knowledge-producing institutions (universities, research institutes, technology-providing firms), bridging institutions and customers, linked in a production chain which creates added value together'. This definition aptly depicts the contemporary role of industrial clusters as spurs of knowledge exchange, social welfare, technological innovation, and economic growth.

Resilience Capacity of Industrial Clusters

Resilience comprises of three main dimensions; namely resistance, absorption, and capacity for restoration, also known as adaptive capacity (Huai, 2017). Kim et al. (2022) linked the adaptive capacity of a cluster to its ability to change its path dynamically, innovate its operations, stabilise in the new environment and re-orientate its specialism. Martin and Sunley (2015) identified three paths in achieving resilience:

- the Malmö-type in which clusters struggle with a short-term loss but regrow in the long run (e.g. Sheffield's transformation into a cultural industrial city, after a decline in the steel industry that had caused urban blight and severe unemployment rates).
- Silicon Valley-type, in which clusters are able to return to their pre-shock growth pattern, and, thus, either remain stagnant or continue to increase (e.g. Silicon Valley which keeps accepting new entries and continues to grow).
- Detroit-type, in which clusters fail to re-organise and restructure their industry after a severe shock, and in extreme cases lead to a decline in the wider region (e.g. the decline of Detroit's automobile industry which had caused the entire city's decline).

A plethora of studies on industrial clusters have examined how resilience can be affected by various factors. For example, Dai et al. (2021) linked the recovery ability of industrial clusters to network density. Lei and Huang (2014) researched how geographical concentration affects knowledge sharing. Lis and Rozkwitalska (2020) explored how knowledge accumulation affects the technological capability of firms within a cluster. Dai et al. (2021) examined how firms that belong to neighbouring clusters may cooperate and increase their resilience.

Automotive Industrial Clusters

Formation of Automotive Industrial Clusters

The formation of automotive clusters refers to the concentration of automotive-related firms, including automakers, parts suppliers, research and other supporting institutions, in a specific geographical region so as to achieve benefits that arise from proximity and collaboration (Stratmann and Dimitrova, 2008). The first clusters appeared in the late 19th century, as certain regions emerged as epicentres of automotive production attracting a pool of skilled labour and utilising readily available raw materials and existing transport networks. Companies like Ford, General Motors, Fiat, and Renault set up production plants near cities, like Detroit, Turin, and Paris where skilled labour and transport infrastructure were already in existence. For example, Detroit, also known as the 'Motor City', became one of the first automotive hubs in early 20th century due to its proximity to iron and steel reserves; the existence of a well-developed road and water transport network;

the availability of local skilled labour with expertise in metalworking, machining and assembly; and the pioneering efforts of entrepreneurs like Henry Ford to increase innovation in the sector. In Europe, cities like Coventry, with a strong tradition in producing bicycles, hosted companies like Daimler and Triumph taking advantage of the local engineering expertise and skilled labour force. It soon evolved into a major cluster producing luxury, high-performance and military vehicles attracting a plethora of suppliers and contributing to the growth of local research and development centres. Soon, German automakers BMW, Mercedes-Benz and Volkswagen established facilities in Munich, Stuttgart, and Wolfsburg utilising Germany's strong engineering tradition and skilled labour. In the aftermath of the WWII, Japan also invested in its automotive sector focusing on lean manufacturing practices, with regions like Aichi and Tokyo becoming major automotive clusters centred around companies like Honda, Toyota and Nissan. In early 21st century, there was a massive expansion of automotive clusters worldwide due to the rising demand for vehicles that was fostered by the rising population and increasing consumers' purchasing power. Regions like São Paulo and Shanghai became significant production hubs, not only due to their strategic location and access to raw materials, but also due to the significant economic growth.

Social Sustainability of Automotive Industrial Clusters

Although the emergence of automotive clusters has been widely attributed to a tendency of manufacturing activity to concentrate geographically, one cannot ignore their strong socially embedded character. Clusters are formed by social groups that share common notions of community that may lie in regional, ethnic, and cultural identities, and are characterised by similar interests, reciprocity, and mutual trust. This results in local social capital that reinforces cluster ties and fosters knowledge exchange, collaboration, and competition (Pinch et al., 2003). Within this context, small businesses specialised in a particular activity embrace the opportunity to passively acquire skills and knowledge and actively generate gains that accrue from the adoption of technological innovations and the exploitation of economies of scale that enhance their ability to compete in global markets (Nadvi and Barrientos, 2004). Such benefits are brought into a sharper perspective in developing countries, where the higher value-adding parts of global value chains, such as car design, marketing, and financial management, are controlled by developed countries and more labour-intensive tasks, such as car assembly and production, are performed in developing countries (Thomsen and Pillay, 2012). Nadvi and Barrientos (2004) examined the relationship between industrial clusters and poverty and concluded that clusters generate employment and income and improve living standards for the working poor. Thomsen and Pillay (2012) also highlighted the contribution of industrial clusters to promoting Corporate Social Responsibility initiatives around labour rights, standard of living, skill building, community welfare, ethical practices and human rights in developing countries.

The Impact of Covid-19 on the Manufacturing Sector

Industry's Response to Covid-19

On 11 March 2020, the World Health Organisation (WHO) declared the coronavirus outbreak a global health emergency (WHO, 2020). In response, a wide range of drastic measures were deployed worldwide to curtail the spread of the virus and minimise social and economic fallout. With most National Health Systems struggling to cope with the profound impacts of the pandemic, authorities around the world rushed to hoard medical supplies before imposing temporary entry and export bans to hinder the introduction of new sources of infection and protect domestic supplies of critical medical and perishable items. In regions with high infection rates, stringent safety protocols of physical distancing and mobility restrictions were introduced, whilst a range of hygiene, case-detection, contact tracing, isolation and quarantine measures were enforced to halt interhuman transmission of the virus. Non-essential workplaces requiring high physical interpersonal interactions were compelled by state-level mandates to close and lay off their employees. These measures had severe impacts on workforce attrition, income turnover, consumption, mental health, and wellbeing.

A New 'Normal' for the Manufacturing Sector

The burst of the pandemic created severe implications on production, supply and demand chains and exerted extraordinary pressures on standard manufacturing cycles and processes. Despite the wide implementation of infection prevention and control measures, critical factory zones, such as production floors, assembly and finishing areas, requiring high occupancy and close worker proximity, became major clusters of workplace outbreak (Raja et al., 2022). This induced a surge in the number of absences of Covid-infected workers which further aggravated longstanding labour shortages and intensified

work for on-site staff. Moreover, productivity was seriously affected by a drastic reduction in the aggregate supply of input materials and equipment to downstream production industries due to factory closures in China, interruptions across global transport networks, and border restrictions (UNCTAD, 2020). Those effects reduced global supply chains responsiveness, causing material prices to rise, retail sales to drop, and plants to slow or cease production altogether. The adverse shocks of Covid-19 on employability, income levels, and household spending heightened financial concerns and the level of mental health issues, such as anxiety and depression. Those impacts were particularly detrimental to the most vulnerable social strata which traditionally form the social bedrock of a production entity including migrants, poor or those with less educational attainment working under temporary contracts, the informal sector, in low-pay, or low-power positions.

Covid-19's Impact on the Automotive Sector

As no industry has been immune to the pandemic's impact, the automotive sector was also hit severely by supply-side disruptions. Plant shutdowns; labour shortages, health and safety measures restricting the number of on-site workers; bottlenecks in shipping; delays in supplier delivery times; automotive producers cutting semi-conductor orders in anticipation of lower demand; and semi-conductor suppliers shifting part of the production to producers of electronic and communication equipment, where sales were soaring, leading to chip shortages; all contributed to large-scale production cuts despite strong global demand (OECD, 2021). Yan et al. (2020) examined how various socio-demographic, epidemic-related and psychological-latent factors affected car purchases during the pandemic. They concluded that Covid-19 generated an adverse rise in demand by females, high-income earners, and those living in high epidemic risk areas. However, it was found that the overall purchase propensity was reduced due to negative income trends. As a result, in a period of 9 months during 2021, global car sales declined by 40% in Japan and the US, 16% in Germany, and 20% worldwide (OECD, 2021). Low inventory levels and solid demand placed upward pressures on the prices of new and used cars, especially in the US and eventually led automakers to significant financial losses. As a result, the sector's workforce faced layoffs, furloughs and reduced work hours contributing to rising unemployment rates. This situation highlighted the need for adaptability and resilience in the automotive sector, but also the need for reskilling and upskilling workers to adapt to the changing landscape and new technologies.

Response of Automotive Clusters to Covid-19

The Covid-19 crisis uncovered the capacity of automotive clusters to spot market shortages, integrate and coordinate different stakeholders, and accelerate existing problem-solving capabilities to bring emergency medical supplies quickly onto the market. By deploying production capacities that were grossly underutilised during the pandemic, many automotive clusters, often in collaboration with the highly specialised pool of multidisciplinary skills in partner Universities and the provision of Government contingency funds (Casper, 2007), developed coherent production strategies by redeploying their employees to create vital equipment for National Health Systems, including masks, PPE and ventilators. Repurposing strategies of this kind not only contributed to regional efforts to support medical teams but were also lifelines for many car factories during periods of forced closure (Aldrighetti, et al., 2001).

While recovering from the 2008 global financial crisis, Detroit's automakers Chrysler and General Motors (GM) returned stronger and started investing in the production of SUVs and trucks, and the research and development of electric and autonomous vehicles. Despite facing a decline in sales during the pandemic, they soon exhibited an uptick in new vehicle production (McLenon, 2021). Stuttgart-based automakers, such as Mercedes-Benz and Porsche producing high-quality luxury and performance vehicles, were experiencing a steady growth until 2019 due to Germany's robust economy and export-oriented approach, unlike Turin's based automakers, such as Fiat, Lancia, Alpha Romeo and more luxury automakers Ferrari and Maserati, that were facing fierce competition and reducing demand. Following the pandemic, both clusters kept expanding their vehicles portfolio focusing on the use of cutting-edge technologies. Tokyo's cluster experienced a mix of growth and challenges after the 2008 global economic crisis and the 2011 earthquake. Sales by Toyota, Honda and Nissan declined sharply during the pandemic, while a special fund was set up to protect jobs. Currently, Tokyo's automakers focus on the production of electric cars, while demand is stable (Regan, 2022). Following China's 1980s economic reform and its opening to foreign investments, many international automakers (e.g. Volkswagen (VW), GM and Ford) formed joint ventures with Chinese partners developing Shanghai's cluster. Despite disruptions in production and parts supply during the pandemic, it soon rebounded its operation with the support of Governmental mechanisms (ChinaDaily, 2022). Similarly, Chennai's, Bangkok's, and Bursa's clusters started hosting foreign investors like Ford, Renault, Honda, BMW, GM, Nissan

and Chrysler attracting numerous component and ancillary firms in the region. All three managed to recover and return to previous growth rates. A similar recovery pattern was noted in São Paulo's, Tychy's and Guanajuato's clusters established in 1950s, 1970s and 1990s, respectively by foreign investors Ford, Fiat, VW, and GM; Fiat; and Mazda, Honda and GM correspondingly due to increasing regional demand and industrial infrastructure. Although production was paralysed during the pandemic, they gradually recover. Togliatti's cluster (AvtoVAZ) is a joint venture between Fiat and Russia which expanded its production capacity and product range over the years. Due to the Russia-Ukraine war, it currently faces production issues due to shortages of parts supplied from overseas (AL, 2023). Same issues are faced in Gothenburg's cluster with Volvo aiming to axe 1,300 jobs to cut costs down despite rise in demand. The growth of Seoul's cluster was fostered by the South Korean Government through financial support and export-oriented policies. Yet, chip shortages and rising interest rates affect current demand for Hyundai, Kia, and GM cars. Coventry's cluster consists of automakers, like JLR, suppliers, and local research institutions, such as the Universities of Warwick and Coventry. Similarly, Graz's cluster involves the Graz University of Technology for the development of automotive related research and expertise often absorbed by local automakers, Magna Steyr, JLR and other.

Location	Launched	Brands	Before	After	Resilience Path
Detroit, USA	Early 1900s	Ford, GM, Chrysler	Growth	Growth	Silicon Valley
Stuttgart, Germany	Late 1800s	Mercedes, Porsche	Growth	Growth	Silicon Valley
Tokyo, Japan	1950-1960s	Toyota, Honda, Nissan	Stagnant	Stagnant	Silicon Valley
Shanghai, China	1980s	Saic, VW, GM, Ford	Growth	Stagnant	Silicon Valley
Turin, Italy	Late 1800s	Fiat, Lancia, Ferrari, etc	Decline	Stagnant	Malmö
Chennai, India	1940-1950s	Ford, Hyundai, Renault	Growth	Growth	Silicon Valley
São Paulo, Brazil	1950s	VW, Ford, GM, Fiat	Growth	Growth	Silicon Valley
Togliatti, Russia	Late 1960s	Fiat, Lada	Stagnant	Stagnant	Silicon Valley
Seoul, S. Korea	1950s	Hyundai, KIA, GM Korea	Growth	Stagnant	Silicon Valley
Bangkok, Thailand	1980-1990s	Honda, Ford, BMW, etc	Growth	Growth	Silicon Valley
Coventry, UK	Late 1800s	JLR, LEVC, Geelys	Growth	Stagnant	Silicon Valley
Graz, Austria	Early 1900s	JLR, Magna Steyr, etc	Growth	Stagnant	Silicon Valley
Tychy, Poland	1970s	Fiat	Growth	Stagnant	Silicon Valley
Guanajuato, Mexico	1990s	Mazda, Honda, GM	Growth	Growth	Silicon Valley
Valencia, Spain	1970-1980s	Ford, GM, VW	Growth	Stagnant	Silicon Valley
Bursa, Turkey	1960-1970s	Renault, Chrysler, etc.	Growth	Growth	Silicon Valley
Mladá Boleslav, Czech	Early 1900s	Škoda	Growth	Growth	Silicon Valley
Ulsan, S. Korea	1960s	Hyundai, KIA	Growth	Growth	Silicon Valley
Gothenburg, Sweden	Early 1900s	Volvo, CEVT, etc	Growth	Stagnant	Silicon Valley
Hsinchu, China	1970-1980s	Chips and electronics	Stagnant	Stagnant	Silicon Valley

Table 1: Resilience capacity of 20 largest automotive clusters worldwide.

Conclusions

The paper highlighted the social identity of automotive clusters and demonstrated how the presence of strong human capital has strengthened resilience against the pandemic. It emphasized how the establishment of solid networks among industries, institutes, and Governments have transformed clusters into avenues for orchestrated regional recovery enhancing the well-being of communities and their capacity in overcoming Covid-19's shocks. Through the examination of the 20 most important automotive clusters worldwide, it exhibited the ability of most to return to their pre-shock growth pattern (Silicon Valley resilience type) by sharing risks and transferring tacit knowledge and technology among their members, while turning into engines of innovation and encouraging recovery and economic growth.

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FACTORS INFLUENCING THAI CONSUMERS TO ADOPT CROWDSIPPING

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1. Introduction

Following the global trends, Thailand's urban growth and development led to severe traffic congestion and pollution, negatively impacting human health, resulting in 6,800 deaths in Bangkok due to poor air quality in 2020 and causing economic losses of 81.4 billion baht (Burton, 2020). Thus, Thailand should decrease the number of vehicles on its roads to benefit its environment and citizens' health. Yet, with increasing e-commerce trends, the traffic may worsen unless eco-friendly delivery methods are utilized.

The increase in e-commerce has led to more traffic for last-mile deliveries, especially during COVID-19 when consumers shifted to online shopping (Chayomchai et al., 2020). In Thailand, online shopping rose from 54% in 2019 to 65.1% in 2022, with a change in purchasing habits towards groceries and second-hand items, causing a 63.3% rise in annual online spending (Kemp, 2019, 2022). Consequently, the demand for delivery services has increased, exacerbating environmental issues associated with delivery logistics.

Crowdsipping is a new model that satisfies the high demand for shipping, particularly last-mile delivery, where couriers use their own vehicles or public transport during their regular travels (Gatta et al., 2018). It mostly caters to takeaway meals and grocery delivery, but it is expanding into other areas (Pourrahmani & Jaller, 2021). Widespread adoption of crowdsipping could alleviate traffic congestion and reduce the environmental impact and shipping costs of last-mile logistics (Mckinnon, 2016). Nevertheless, as will be discussed further in the literature review section, behavioural research exploring the factors that influence the use of crowdsipping services are lacking due to its recent emergence.

Recently, many Asian nations have shown an increasing interest in crowdsipping resulting in the launch of several new crowdsipping services to meet the rising demand for deliveries (Mckinnon, 2016; Pani et al., 2022). However, despite the potential environmental and health benefits, there is a lack of research on crowdsipping in Asia. The lack of research in Asia can be attributed to the fact that crowdsipping was more popular in Western nations, especially before the COVID-19 pandemic triggered a global shift towards more online purchasing (Jeremić & Andrejić, 2019).

Due to the limited number of studies on crowdsipping adoption, there is a lack of information available on crowdsipping acceptance, especially in Asia. Thus, this research aims to fill this gap by examining the impact of demographic, technological, service-based, and consumer factors on crowdsipping adoption in Thailand using Structural Equation Modelling (SEM).

Section 2 of this paper presents the state of the art of behavioural research relevant to crowdsipping and the conceptual model proposed in this study. Section 3 discusses the data collection and analysis process. The result of data analysis is then presented in section 4. Section 5 provides conclusion and proposes potential future research.

2. Literature Review

2.1 Crowdsipping Acceptance Research a State of the Art

Le et al. (2019) reviewed 57 crowdsipping-related research papers and found that only about 12% of the studies had investigated the behaviour of stakeholders in this system. Gläser et al. (2021) reviewed 61 research papers and reported that only about 23% of the studies had examined factors affecting the acceptance of crowd logistics initiatives. Therefore, studying the behavioral aspects that influence crowdsipping acceptance remains an important topic.

Table 1 summarises relevant previous behavioral research on crowdsipping acceptance, categorized by case study (Case) and economic development level (Eco.Dev (The World Bank, 2021)). The studies are also classified as users or drivers (Pers), with users indicating whether a study measure the willingness of consumers to use a crowdsipping platform as a sender or receiver, and drivers indicating whether a study measures the willingness to participate as a courier or driver. Finally, the previous studies are categorized based on the theoretical lens that have been adopted.

Table 1: Summary of previous studies based on the case, economic development, perspective and theory. Eco.Dev: Economic Development; HI: High income countries; LMI: Lower middle income countries; UMI: Upper middle income countries; Pers: Perspective; SN: Social network; UT: utility theory; SIT: Social Identity Theory; TRA: Theory reasoned action; PPM: Push–Pull–Mooring Theory; TAM: Technology acceptance model; DOI: Diffusion of innovation; N/A: Not mentioned.

Authors	Case	Eco.Dev	Pers	Theory
Devari et al. (2017)	US	HI	Driver	SN
Miller et al. (2017)	US	HI	Driver	UT
Punel and Stathopoulos (2017)	US	HI	User	UT
Gatta et al. (2018)	Italy	HI	User	UT
Punel et al. (2018)	US	HI	User	UT
Ta et al. (2018)	US	HI	User	SIT
Felch et al. (2019)	Germany	HI	User	TRA
Le and Ukkusuri (2019a)	US	HI	Driver	UT
Le and Ukkusuri (2019b)	US	HI	Driver	UT
Huang et al. (2020)	China	UMI	Driver	PPM
Buldeo Rai et al. (2021)	Belgium	HI	User	N/A
Wicaksono et al. (2022)	Netherland	HI	User; Driver	UT
Huynh et al. (2021)	Vietnam	LMI	User	TAM, DOI
Truong (2023)	Vietnam	LMI	User	DOI

Table 1 indicates limited research in lower or upper-middle-income countries especially those in Asia. Most of the prior studies are dominated by economic theories, specifically utility theory (about 50%), with a lack of studies employing psychological or information systems theories like TRA or TAM. Our study, like most prior studies, is user-focused, but it is unique in its focus on Thailand as an upper middle income country in Asia, and in its use of a consumer behaviour theory, namely TAM combined with additional namely, demography, personal innovativeness, trust and price.

2.2 Technology Acceptance Model (TAM)

TAM specifies causal relationships that impact technology adoption (Davis, 1989). According to TAM, external factors influence Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), which in turn affect attitudes. Attitudes then determine intentions, which predict actual system use. PEOU can also directly affect PU, and PU can directly impact attitudes. Thus, TAM suggests that the likelihood of adopting a new technology depends on interplay of factors that lead potential users to believe that the technology is easy to use (PEOU) and beneficial for achieving desired goals (PU), resulting in a positive attitude toward it.

The original factors in TAM and the hypotheses to be tested in this paper are:

1. Perceived Usefulness (PU): PU, or the belief that technology can improve task performance, directly impacts crowdshipping adoption (Felch et al., 2019) and acceptance. Although no studies specifically investigated how PU affects attitudes toward crowdshipping, research in other areas has suggested a connection between PU and attitudes towards technology adoption.

H1: PU influences attitude toward crowdshipping system use.

2. Perceived Ease of Use (PEOU): PEOU is consumers' perception of the effort required to use a new technology (Chen et al., 2011). Huynh et al. (2021) has found that PEOU significantly influenced consumer attitudes towards mobile shopping using a crowdshipping platform.

H2: PEOU influences attitude toward crowdshipping system use.

3. Consumer Attitude (Att): Attitudes are evaluations of things as favourable or unfavourable and are a predictor of intentions and subsequent behaviours according to the TAM (Davis, 1989). Two studies examined general attitudes as a predictor of behaviour in crowdshipping. Buldeo Rai et al. (2021) found that consumers who preferred at-home delivery and can rely on their neighbors in case of failed deliveries were most likely to adopt crowdshipping. Huynh et al. (2021) concluded that attitudes predicted the likelihood of repeat purchasing through a crowdshipping app.

H3: Attitude influences intention to use a crowdshipping system.

4. Intention to Use (IU): According to TAM, intentions do not always accurately predict behaviors, although the two are strongly correlated (Yousafzai et al., 2007). Intentions to continue a behavior may not always be fulfilled due to various reasons such as difficulty, social pressure, forgetfulness, procrastination, distractions, lack of willpower, and even life events (Sheeran & Webb, 2016), even though, stronger intentions are more likely to result in actual behavior. The TAM proposes that intentions should predict behaviors (Davis, 1989).

H4: Intention to use is positively related to crowdshipping system use.

4.3. Other factors influencing the acceptance of crowdshipping

In addition to the original factors in TAM, listed in section 2.2, this paper also analysed other factors that might influence the acceptance of crowdshipping. These factors are:

1. Trust (T): Online shopping and delivery services come with many risks (financial, privacy, time-loss and product related problems) that may discourage customers from using them (Ashrafi et al., 2020). Trust factors such as perceived security and privacy (Felch et al., 2019), and driver experience and real-time tracking (Punel & Stathopoulos, 2017) affect crowdshipping affect usage intentions, preferences and behaviors. However, Huynh et al. (2021) is the only study that have explicitly examined the positive relationship between trust and attitudes toward crowdshipping platform.

H5: Trust influences attitude toward crowdshipping system use.

2. Price (P): Research has shown that price is an important factor that influences the likelihood of using crowdshipping services (Punel et al., 2018). Studies have mainly investigated the direct impact of price on usage intentions, or through consumer satisfaction (for example Huynh et al. (2021)), but Yeo et al. (2017) found that price can also affect usage through attitudes toward delivery services.

H6: Price influences attitude toward crowdshipping system use.

3. Personal Innovativeness (PI): PI, referring to the ability to rapidly adapt to new technologies and embrace them (Ashrafi et al., 2020). Huynh et al. (2021) is the only study that has explored PI in the context of crowdshipping, and they found that PI indirectly influenced attitudes towards crowdshipping via PEOU and trust. Hence, it is expected that PI will positively impact attitudes towards crowdshipping.

H7: PI influences PU of crowdshipping system.

H8: PI influences PEOU of crowdshipping system.

H9: PI influences trust toward crowdshipping system.

H10: PI influences perception toward crowdshipping price.

4. Demographic factors: Two studies have investigated the impact of demographics on crowdshipping acceptance. Punel and Stathopoulos (2017) and Punel et al. (2018) found that crowdshipping use was higher among males and younger individuals. However, these studies did not explore the impact of education level on crowdshipping adoption.

H11: There are significant age differences in crowdshipping system use.

H12: There are significant gender differences in crowdshipping system use.

H13: There are significant education level differences crowdshipping system use.

4.4. Conceptual Framework

The conceptual model (Figure 1) illustrates the relationships proposed by the 10 hypotheses. The model incorporates predictors of attitudes such as PI, trust, and price, in addition to the TAM's original predictions that PU and PEOU influence attitudes, which lead to intentions and actual system use. Also, in contrast to Huynh et al. (2021), this research assumes that price directly affects consumers' attitudes. The model also suggests that actual system use may vary by demographic factors.

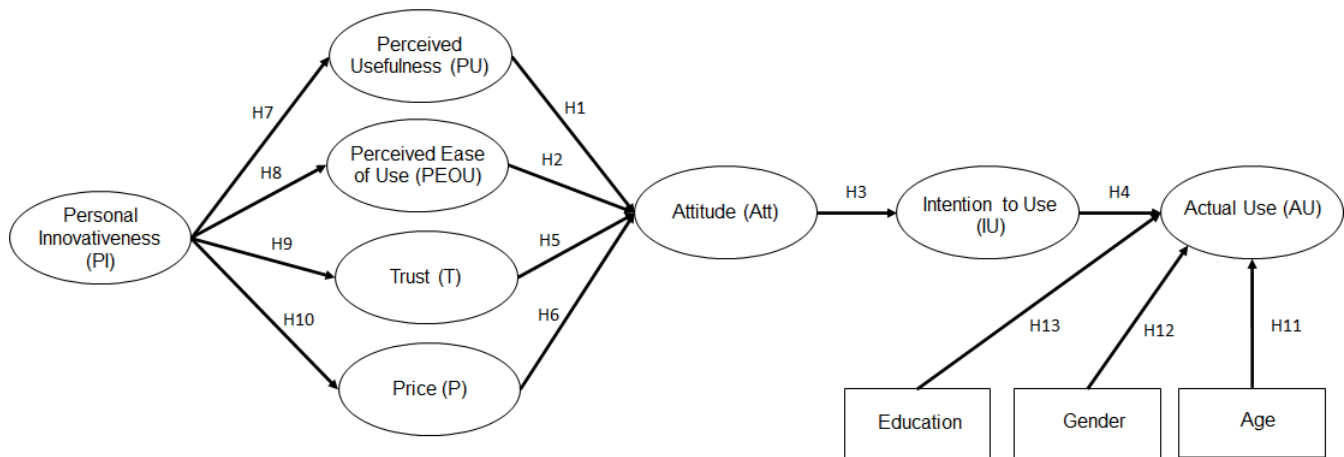


Figure 1 Conceptual model

3. Methodology

3.1. Data Collection

A survey was designed to measure variables affecting crowdshipping adoption. We used likert-scale questions adapted from relevant studies such as Ha and Stoel (2009), Shafiq et al. (2011), Yeo et al. (2017), Ali et al. (2020), and Huynh et al. (2021). This questionnaire was then distributed to the potential respondent as an online survey. We consider online survey as an efficient data collection method for both the researcher and participants and allows for a larger and more representative sample. This method also offers the benefit of anonymity, convenience, and safety during the ongoing COVID-19 pandemic. 297 samples mainly from Bangkok Thailand were obtained. The collected data were then tabulated and analysed using IBM SPSS. After assessing the collected surveys for accuracy and completeness 253 samples were retained for further analysis.

3.2. Sample Characteristics

The sample consists of 55.9% female respondents, 43.1% male respondents and 1% of the respondents preferred not to mention their gender. 48.1% of the respondents are below 41 years old. 81.5% of the respondents have at least obtained a bachelor degree, hence this sample can be considered to represent highly educated consumers in Thailand. With regards to income, 85.9% of the respondents earn more than 15,000 THB monthly indicating that this sample represents medium to high income consumers. And 67% of the respondents use crowdshipping service at least once in every two weeks.

3.3 Hypotheses Testing Results

Hypothesis testing was carried out using IBM SPSS AMOS 29. The SEM model fitting produced CMIN/DF of $2.349 < 3$ indicating an acceptable fit. The Goodness of Fit Index (GFI) of our model is sufficiently high namely, 0.806. The Comparative Fit Index of our model is 0.897 which is also sufficiently high. Our model has Parsimony Comparative Fit Index (PCFI) of 0.795, indicating high likelihood of a more parsimonious model that can explain the actual crowdshipping system use. The RMSEA (Root Mean Square Error of Approximation) of our model is 0.073 which is acceptable.

Table 2 shows the result of the hypotheses testing. It shows that all relationships are significant at 5% significance level except for H2, H11, H12 and H13.

Hypotheses				Estimate	S.E.	C.R.	P
1	Att	<---	PU	0.204	0.067	3.066	0.002
2	Att	<---	PEOU	0.097	0.065	1.485	0.138
3	IU	<---	Att	1.12	0.084	13.262	***
4	AU	<---	IU	0.894	0.052	17.328	***
5	Att	<---	T	0.23	0.069	3.311	***
6	Att	<---	Price	0.313	0.049	6.326	***
7	PU	<---	PI	0.802	0.08	10.082	***
8	PEOU	<---	PI	0.863	0.082	10.554	***
9	T	<---	PI	0.686	0.075	9.122	***
10	Price	<---	PI	0.632	0.089	7.123	***
11	AU	<---	Age	-0.001	0.003	-0.562	0.574
12	AU	<---	Gender	0.069	0.058	1.185	0.236
13	AU	<---	Years_Formal_Edu	-0.012	0.009	-1.28	0.201

Table 2 Structural model for hypothesis testing results

4. Discussion

The survey responses indicate that in common with other Asian nations, many Thai consumers have used crowdshipping services in the past and will continue to do so regularly. Our model shows that the actual crowdshipping system use is influence mainly by the consumers' intention to use, while demographic factors have no significant influence. One potential explanation is because the adoption of crowdshipping has been spreading throughout the population over the past few years due to word-of-mouth and the high demand for delivery services. This might have eliminated the significance of demographic factors.

Other research relevant to crowdshipping have usually omitted attitudes from their research models. However our study shows that attitude is an important predictor of consumers' intention to use crowdshipping platform. This is in alignment with the findings of other crowdshipping adoption studies such as (Buldeo Rai et al., 2021). In common with Huynh et al. (2021) our SEM model fitting shows that PU significantly influence consumers' attitude hence the intention to use crowdshipping platform. However this is not the case of PEOU. One of the possible explanation is because Huynh et al. (2021) used the case of brick and mortar crowdshipping, in which the consumers use the crowdshipping platform less regularly than in our case. Other variables that positively influence consumers' attitude are perception toward price and trust. Among those three variables perception toward price is the one with the strongest influence. This indicate that it is very important for a crowdshipping service provider to offer a price that is acceptable for the consumers.

Personal innovativeness variable positively influence perceived usefulness, perception toward price and trust toward crowdshipping platform. This indicates that a highly innovative person will be more convenience to use crowdshipping platform.

5. Conclusions and Future Research

This research has examined trends in crowdshipping system use and the factors that contribute to crowdshipping adoption among Thai consumers. An online survey was conducted, and the survey data have been analysed to test a predictive research model for crowdshipping adoption in Thailand. The data shows that many Thai consumers have used crowdshipping services and those who have adopted crowdshipping use these services regularly. Moreover, Thai consumers tend to have generally positive attitudes toward crowdshipping, viewing the services as convenient, and reasonably priced. However Thai consumers also tend to be price-sensitive, so the majority would probably be deterred by higher delivery costs.

We have also identified the factors that contribute to crowdshipping adoption in Thailand. Statistical analysis using SEM indicates that attitudes toward crowdshipping are influenced by PU, trust, and price, while all of these variables are positively influenced by PI. This indicates that PI plays indirect role in crowdshipping adoption in Thailand i.e., improving the positive perception toward crowdshipping usefulness, trust and price. Attitudes predict intentions to use crowdshipping, which in turn predict actual system use. However, although these correlations are strong, not all those who have positive attitudes toward crowdshipping intend to use these services, and some who intend to arrange deliveries via crowdshipping do not follow through. This indicates that there are other factors not included in the research model that can intervene in these relationships.

This research also sought to determine whether crowdshipping adoption in Thailand varies based on age, gender, or education level, but no demographic differences in adoption rates were found. The lack of demographic differences in crowdshipping adoption may be unique to Thailand. However, it could also indicate that crowdshipping has become more accepted among a wider range of people in recent years due to increased familiarity with the concept and the need to meet rising demand for delivery services.

The consumers' behavioural model elicited in this study can be used in more advance modelling techniques such as agent-based modelling and simulation (ABM). ABM can aid to design robust and optimal crowdshipping system by considering human behaviour. ABM has been employed in relevant areas such as last-mile delivery (e.g., Utomo et al. (2021)) and food supply chain (e.g., Utomo et al. (2018)), but its application in crowdshipping is currently lacking.

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IOT – BLOCKCHAIN INTEGRATED PLATFORM FOR MARITIME SHIPPING: APPLICATIONS, ADOPTION, AND ARCHITECTURE.

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1. Introduction

Maritime logistics is a vital part of today's economies. The UK Department of Transport estimated in 2015 that shipping and ports generate up to 14 billion pounds in revenue and provided more than 250,000 jobs (Department of Transport, 2015). Furthermore, maritime logistics has strong impacts on the environment. The UK domestic maritime vessels represented around 5% of the UK's domestic transport Green-House Gases (GHG) emissions in 2020 – more than domestic rail and bus emissions combined (Maritime UK, 2022). The International Maritime Organisation – a United Nations specialised agency – sets the ambition to reduce 40% of CO₂ emissions per transport work by 2030 compared to 2008 across international shipping. Among the work plans issued by the agency to achieve the said aim, the Annex 19 – Resolution MEPC.323(74) specifically invites Member States to support “the industry's collective efforts to improve quality and availability of data and develop necessary global data standards that would allow reliable and efficient data exchange between ship and shore” (MEPC 74/18/Add.1 Annex 19, p2), signifying the importance of improving information sharing for operation excellence and emissions reduction in the maritime shipping.

In the wake of Industry 4.0, the maritime shipping industry has explored various digitalization tools, such as Blockchain, IoT, and data analytics, to minimize expenditure, optimize operations, and increase the level of competitive advantages (Gavalas et al., 2022). To this end, an Internet of Things (IoT) and Blockchain-integrated platform provides a novel and exciting solution, with promising benefits to the maritime shipping industry. In this context, IoT can be understood as a set of smart and interconnected sensors embedded in the containers, with the role of automatically collecting and transmitting information on various maritime logistics facets. Blockchain, an innovative distributed ledger technology, acts as a data repository and sharing layer. Information on Blockchain is secured, reliable, and available in real-time (Wang et al., 2019). Together, this novel combined solution seeks to provide a holistic platform for container traceability, digitalize the maritime shipping operation, and record Co₂ emissions in a reliable and trustworthy manner. Recognizing the potential of an IoT and Blockchain integrated solution, this research aims to explore the following research questions (RQs):

RQ1: How can the solution improve operational challenges in seaborne shipping?

RQ2: How can the solution contribute to sustainability in maritime shipping?

RQ3: What is a feasible conceptual architecture of such a solution for maritime shipping?

To answer these RQs, the authors conducted in-depth semi-structured interviews with experts in the field to gather empirical insights. Findings uncovered specific uses and mechanisms by which an IoT and Blockchain-integrated solution can improve maritime shipping operations and emissions monitoring. Further, together with experienced developers, an architecture of such a solution is constructed. Overall, the findings in this study expand the current understanding of transformative technologies' application in maritime shipping and inform managers in the field of IoT and Blockchain adoption.

2. Background

Overview of maritime shipping operation

As container transport is well understood in practice, the practitioner literature is extremely useful for providing insights into the physical flow of containers in maritime shipping. The end-to-end movement of a container can be summarized in six key phases, according to Trade Finance Global (2023):

1. *From customer to forwarder: goods are transported to forwarder from the customer.*
2. *From forwarder to port: goods moved from forwarder to ports.*

3. From port to carrier: goods are containerized at this point, and containers are loaded onto the vessels.
4. From carrier to destination port: containers are unloaded into the discharging port.
5. From port to last mile shipper: from the receiving port, the containers are picked up by the next link of the transport process.
6. From last-mile shipper to final consignee: containers are delivered.

An IoT and Blockchain integrated solution

A solution developed by MCG UK Ltd, in partnership with the research team in this study, was used as the baseline in this study. This solution contains two main parts. Smart containers, equipped with sensors and data transmission technology, act as the physical layer for collecting and sending information. Vital information about the cargo such as the surrounding conditions (i.e. temperature and humidity) and locations are captured by this layer. Blockchain acts as the underlying technology for the digital layer, which stores, secures, and shares data instantly with stakeholders. Together, the two technologies comprise a comprehensive solution that can gather, monitor, and communicate data with high accuracy and reliability. Figure 1 summarizes the structure of the solution.

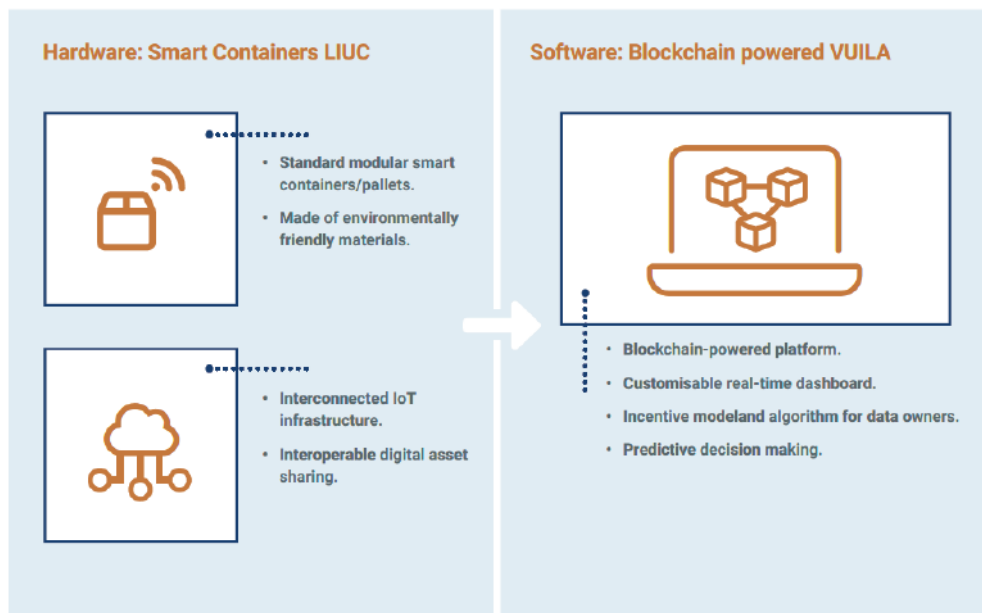


Figure 1. IoT and Blockchain integrated solution.

3. Methodology

This study adopts a qualitative approach. Empirical data was collected using semi-structured interviews with experts in the maritime shipping industry. The use of qualitative data is sufficient for two reasons. On one hand, there is a lack of knowledge about the application of disruptive technologies such as Blockchain in the maritime shipping industry (Papathanasiou et al., 2020). To this end, qualitative methods and analysis are particularly useful for exploratory works, allowing explanation, clarification, and exploration of concepts and meanings to be construed in under-explored contexts (Saunders et al., 2009). On the other hand, exploring the potential and other facets of adopting a novel IoT & Blockchain solution requires appropriate perspectives from experienced professionals in the field. The subject at hand is arguably emerging, complex, and sector-specific. Therefore, the viewpoints of experts are critical to providing valuable insights about the maritime shipping sector and the prospects of MCG UK's solution.

A panel of experts was contacted. Participants (Ps) of this panel have extensive experience working in maritime logistics, especially in bulk transport such as containers and oil tankers. There are 6 experts in total, and 7 interviews were conducted virtually. Table 1 describes the participants of this project. 75 pages of transcripts were generated at the end.

Table 1. Overview of experts.

	Position	Experience	Interview
P1	Lead maintenance engineer at a large international shipping enterprise.	5 years	Number: 1 Duration: 60 minutes
P2	Navigation and operation lead at a leading international oil seaborne transport organization.	10 years	Number: 1 Duration: 75 minutes
P3	Vice-chair at a maritime transport-specific consulting group.	30 years in transport, logistics, and supply chain. 15 years in developing standards in the maritime environment.	Number: 2 Duration: 60 minutes each.
P4 Professor of transportation engineering.	Deputy director of the container transportation committee, part of the Port Association in the participant's resided country. Professor of transportation engineering.	4 years as the committee's deputy director. 10 years of maritime transport experience.	Number: 1 Duration: 60 minutes.
P5	CEO or a cargo handling service company in China	12 years	Number: 1 Duration: 40 minutes
P6	Port optimization manager in a global shipping enterprise.	10+ years	Number: 1 Duration: 50 minutes

4. Findings

The data analysis process

Two members of the research team were tasked with analysing the interview transcripts. Governed stringently by the research questions, the researchers focused on the mechanisms by which the integrated solution can improve operation and sustainability in maritime shipping. For each datum, the researchers used a code (a concept, terminology, or phrase) to concisely capture the overall meaning. Later on, those concepts were grouped under broader themes. The two researchers involved in this task compared notes and their coding results. The results were discussed again among the whole team for the final use of concepts and the arrangement of themes. Interestingly, one more theme emerged from the data, that the team decided to include in the concluding results. This theme is about the “drivers and barriers” to the potential adoption of such an integrated solution. Since these insights are frequently mentioned during the interview, the findings cannot be overlooked. Figure 2 summarizes all key themes that emerged from the empirical data.

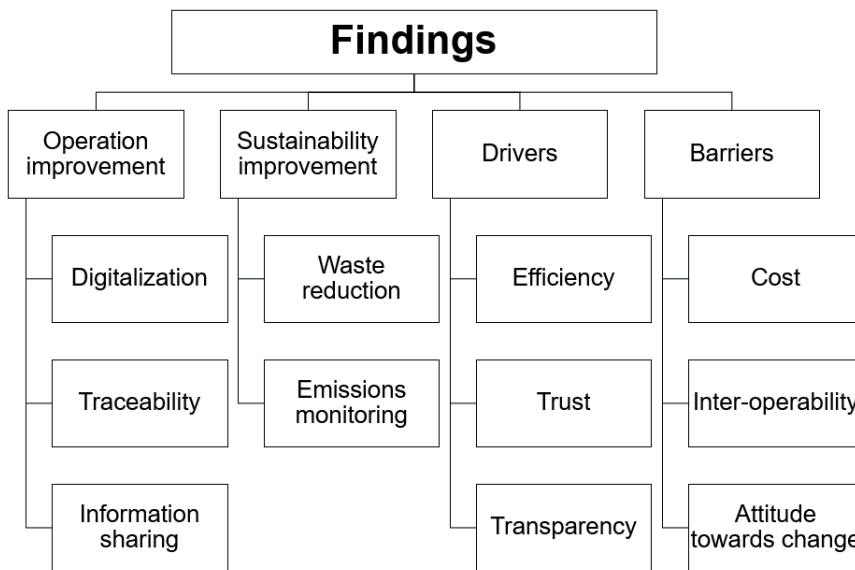


Figure 2. Overview of the findings.

Improving maritime shipping operation

The expert interviews provided interesting ideas and discussions about how the integrated solution can be applied to improve maritime shipping processes. Insights from the data indicated that an IoT and Blockchain integrated solution can greatly improve three key areas of operation, namely digitalization of documents, container traceability, and information sharing.

Due to legal requirements and the norms of the industry, many vital documents are prepared and signed manually. These documents then are scanned and distributed electronically from a central processing system, which is typically hosted by a single stakeholder. P3 stated that “manually processing important documents is dominant in the industry. This can be time-consuming, and error-prone. Having an effective means to digitalize and share documents between stakeholders would cut these cases and improve efficiency considerably”. To this end, IoT & Blockchain can digitalize important documents and automate the communication of critical information to relevant parties, saving time and labour. P2 raised a very interesting example, in which the formulation and circulation of the critical Bill of lading (BL) could be fully automated by using IoT and Blockchain. Sensors in smart containers can automatically verify whether a container is loaded into a vessel, report the contents to the system, and Blockchain allows responsible parties (e.g., crew members) to create and sign the BL virtually. Blockchain further allows the dissemination of such a BL to all relevant stakeholders (e.g., customer, carriers, port operators, customs, etc) instantaneously with a high level of security and accountability. This application of IoT and Blockchain can be expanded to digitalize other vital documents during the maritime shipping process, not only speeding up the distribution of these documents but also avoiding situations where physical copies are damaged during the trips. P2 recalled “important documents frequently get physically damaged during shipping or lost over time.”

Container traceability is another area in that an IoT and Blockchain integrated solution can create positive impacts. In today’s maritime shipping business, customers desire more than a simple report of containers/vessels’ location at a specific time. “Customers always want to know more, not just where, but what is the current state of my goods. So technologies like smart containers and Blockchain are very necessary” – P5 shared. Furthermore, Blockchain can further add another layer of trustworthiness and security on top of the current tracking process. P1 viewed this as an essential capability, stating “Blockchain is a good transformation because of its immutability. You cannot change the data that has been logged. It will bring a lot of transparency against manipulation”.

Digitalization of documents and container traceability allude to the challenge in a broader area of maritime shipping operation, which is information sharing. The information on maritime shipping operations is typically in silos. This means that many stakeholders either do not have or are delayed in getting access to data. P4 shared that “the concept of the IoT and Blockchain solution will be very useful. Especially, I think the best aspects are the decentralization, security, openness, and transparency of Blockchain”. To this end, Blockchain can act as a single and unified source of data between various parties, making sure that everyone is on the same page at the same time.

Improving maritime shipping sustainability

The topic of sustainability in maritime shipping sparked great interest in all of the interviews, as all participants acknowledge the importance of this aspect and have experienced how it affects their companies. P3 and P6 extensively reviewed this topic and listed various actions toward reducing the environmental footprints of seaborne shipping. Examples include the use of green fuel (biofuel, hydrogen, etc), the design and manufacture of new vessels, the monitoring of current fuel usage, the desire to better-plan vessel arrivals and departures to reduce travel time. Insights from the interviews highlighted that an IoT and Blockchain integrated solution can strengthen some, but not all approaches towards sustainable maritime shipping.

First, using IoT and Blockchain combinations can help reduce waste during transport. P6 stressed that maritime shipping is “a crucial component of numerous supply chains of the world. As our customers are heading toward a more sustainable supply chain, we also need to fulfill our parts and become more sustainable”. Food and other perishable and temperature-sensitive products (such as pharmaceutical supplies) are prime candidates for waste reduction using an IoT and Blockchain integrated solution. Actions can be taken immediately to make sure the storing conditions (temperature, moisture, etc) of perishable goods are optimal at all times, as the solution can monitor those conditions in real time. Further, appropriate planning and actions can be orchestrated to efficiently handle goods that were stored in out-of-ideal conditions for a period of time. P3 further added that “this approach does not limit to perishable products. For instance, goods that are physically damaged during shipment can be offloaded before final destination, helping with fuel consumption and ultimately the sustainability of maritime shipping”.

Second, the monitoring of vessel emissions during transport can be enhanced with the use of IoT and Blockchain. P2 shared that “due to environmental concerns, the consumption of fuel and what type of fuels we used are under strict scrutiny. However, it is difficult to keep track of what is going on in the sea”. P1 anticipated that “Blockchain platform can provide a single source of truth for everyone, such as customers, shipping lines, etc. This can particularly be useful when companies calculate CO₂ and other greenhouse gasses emissions”. Currently, emissions (CO₂, NO_x, and other harmful gasses) pose the biggest concern regarding the environmental impacts of maritime shipping. Therefore, an automatic and trustworthy solution for monitoring emissions would certainly benefit the industry as a whole. P6 further recommended that “future expansion of sensors and Blockchain can look to address other sustainability aspects such as the discharging of ballast water or preventing the introduction of unwanted marine species to new territories”.

Drivers and Barriers

Finally, during the interviews, drivers and barriers to the adoption of an IoT and Blockchain solution were explored.

Regarding drivers for adopting an IoT and Blockchain integrated solution, interviewees mentioned potential advantages and improvements brought by the solution such as efficiency and effectiveness, trust, and transparency. By reducing the amount of manual work and physical checks of containers, the solution can boost the efficiency of maritime shipping operation. Further, with the availability and reliability of information shared with Blockchain, certain process such as quality checking can be made more effective. When information can be automatically collected and instantly disseminated through a combination of IoT and Blockchain, the trust between stakeholders of the shipping process is enhanced. Finally, Blockchain can increase the overall transparency of maritime shipping operation and sustainability by disclosing information with reliability and immutability.

Several barriers were identified by the experts when considering this type of technological innovation. Cost is mentioned by all interviewees, as this is a fundamental but detrimental aspect of adopting any new technology. The experts expressed that the margin of maritime shipping is not large, hence companies certainly have to consider their return on investment with care. Another major challenge is interoperability. P3 reminded that “a large part of the industry includes SMEs, the solution needs to be configured in a way that inter-operate across their infrastructures as well”. Finally, P1 warned that maritime logistics can be traditional at times, and there would be frictions to adopting novel technologies coming from persons and organizations’ cultures.

Towards a conceptual architecture of an IoT and Blockchain solution in the maritime shipping industry

For the final objective of this study, the research team discussed and brainstormed with the technology development team of the industry partner to construct an architecture of an IoT and Blockchain integrated solution, for the specific setting of the maritime shipping industry. This architecture has five main layers (IoT physical layer, connectivity layer, data layer, application layer, and business layer), and two complementary layers (smart contract and legacy system). Figure 3 depicts the architecture.

The system initiates with the IoT physical layer. This includes the smart container component and a sensor data management component. The main responsibility of this layer is to collect and pre-process information on-site, before transferring information to the data layer. The connectivity layer includes the communication modules that help transmit the data collected in the IoT physical layer to the data layer via the Internet. There are a number of solutions for data communication, such as WiFi, local bridge, long-range radio, etc. Given the specific characteristics of the maritime industry, in which the majority of the containers' journeys are at sea in vessels, the broadband cellular network is most feasible. The data layer is the critical component of the solution as it collects and processes all the data. An important design decision is made at this layer, which is to employ an on-chain/off-chain database structure. First, all the cumulative data generated by the smart containers are transmitted to an off-chain database. Second, selected data is input into an on-chain Blockchain system, by which it is stored, secured, and distributed to all stakeholders.

Although not part of the main layers, it is important to discuss two layers that support the solution. The first one is the smart contract layer. A smart contract is a distinguished concept from Blockchain technology. When a smart contract utilizes the trustworthy and secured information provided by the Blockchain system, its security and reliability are massively increased. In this specific case, the smart contract can be used to predefine the validation requirement for information to be stored on Blockchain, or automate processes such as payments. The second one is a legacy systems layer. According to the interviews, there is further information that maritime shipping stakeholders would like to store and share on the Blockchain layer. Co2 and other GHG emissions were specifically mentioned by experts as critical information to the industry. Further, since the transition to smart containers typically will happen gradually, container tracking information during the transition period still needs to be taken from existing systems.

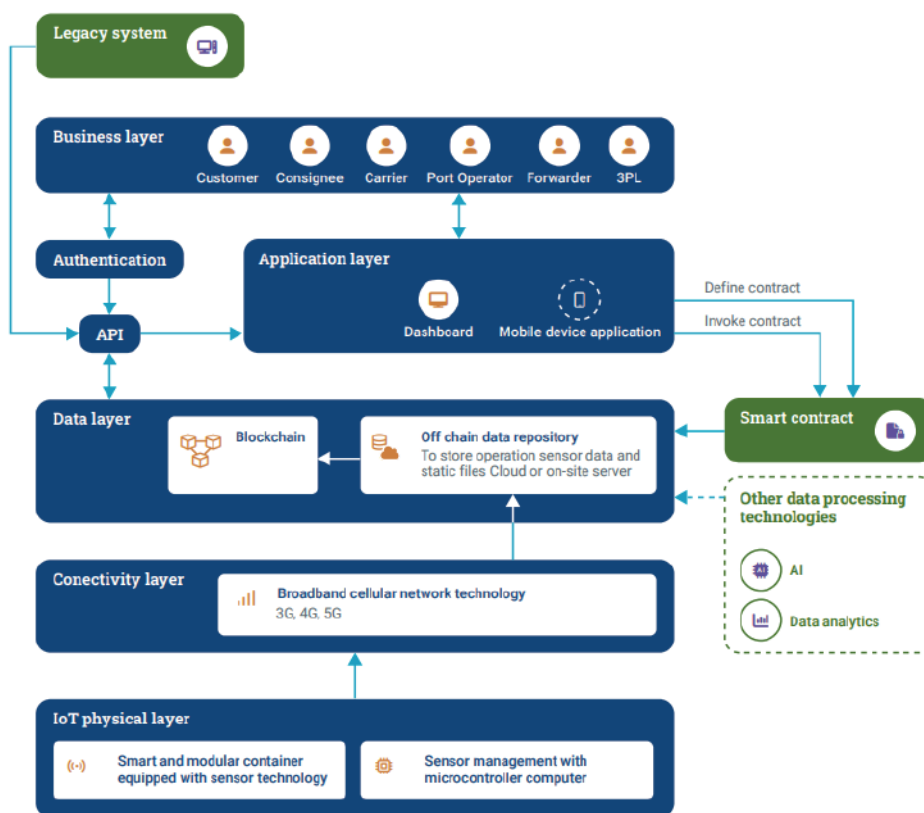


Figure 3. An architecture for the integrated IoT and Blockchain solution.

5. Conclusion

In this study, we investigate various aspects of an IoT and Blockchain integrated solution in the context of maritime shipping industry. As each technology has their own unique capability (e.g., automatic data capturing with sensors, and secured information sharing with Blockchain), we anticipate that a combination of the technologies will bring tremendous benefits to practice. Taking the setting of maritime logistics, we investigate the mechanisms by which the novel solution can improve operation excellence and sustainability of the industry. Further, a set of drivers and barriers to the adoption of such a solution are provided to extend the current understanding about an IoT and Blockchain integrated application. Our study is concluded by presenting a holistic conceptual architecture of the solution.

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EXPLORATION ON THE APPLICATION STATUS OF BIG DATA IN SUPPORTING HEI'S LOGISTICS AND OPERATIONS MANAGEMENT ACADEMICS' KNOWLEDGE ENRICHMENT AND COMPETENCE ENHANCEMENT

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This paper reports a research agenda and its preliminary research work, focusing on the exploration of the application status of Big Data concept and technology in supporting logistics and operations management academics in their knowledge and competence enrichment and development in higher education institutes (HEIs). The research intends to consolidate findings based on the comparative analysis on the data collected from eight universities located in China, UK and Denmark respectively. The data will be obtained through semi-structured interview following a multiple case study strategy. This paper mainly presents the development of the research questions to be investigated and the attestation of their appropriateness through a pilot expert survey.

Keywords: Big Data, higher education institute, case study.

1. INTRODUCTION

As a very popular terminology, Big Data (BD) has been discussed and is being increasingly implemented by both academic and practical organizations. In general, BD refers to huge amount of data, including both structured and unstructured, collected and captured from a variety of internal and external sources (Griffore, 2018; Baig, et al., 2020).

Nonetheless, there is also different understanding with regard to BD as a concept and its

“connotation (Chaurasia, et al., 2018). Some researchers deem that BD focuses more on the technologies and techniques that can process huge amount of data with efficacy and provide value through the processing. While the aspect of BD with regard to the implementation of techniques and technologies to analyze data are referred as BD analytics, which include two dimensions: predictive analytics and prescriptive analytics (Griffore, 2018).

Albeit the definition on BD lacks of a consensus, the implementation of BD concept and the BD analytics in supporting business performance enhancement and improvement has been advocated of its meaningfulness in different fields by researchers (Rezaee, et al. 2018; Chaurasia and Rosin, 2017), where higher education (HE) is one of them (Li and Jiang, 2021). However, the application of BD and its analytics in HE sector is still at an early stage, leaving various aspects to be further explored (Chaurasia and Rosin, 2017; Li and Jiang, 2021). Corresponding to the situation as such, in this paper with a general focus on higher education institutes (HEIs) and a concrete lens on BD's facilitation to the work efficacy and competence development/enhancement of academics in the fields of logistics and operations management, the authors report a research agenda with the preliminary stage exploration outcome, highlighting some key elements deserving substantial further research, consequently directing next stage research actions.

The paper is organized as following: next section is the brief of the literature background of the research, then the introduction of methodology follows, after which is the preliminary stage research outcome - attestation/confirmation of the appropriateness of the research questions, the summarization and the debrief of the next stage research activities finalize the paper.

2. LITERATURE BACKGROUND OF THE RESEARCH

2.1 Understanding of BD concept in HEIs

Ever since late last decade, BD as a business concept has become more and more popular in different industries (Waller and Fawcett, 2013; Chaurasia and Rosin, 2017; Li and Jiang, 2021). Hitherto the understanding of BD has not reached a consensual situation with regard to its content elements and focus, with some people seeing it solely as a huge set of diversified data, while some others seeing it as the data processing technologies/techniques (Rezaee, et al., 2018; Chaurasi and Rosin, 2017; Griffore, 2018). Nevertheless, the demand and implementation of BD see a very fast increase in various business organizations (Chaurasi and Rosin, 2017; Hartmann, et al., 2016; Baig, et al., 2020). While the authors in this paper deem that in order to harness the benefits from BD, a clear understanding of BD concept cannot be independent to the apprehension of BD analytics, which is through the application of relevant software and approaches to distill the relevant knowledge and identify patterns from the various data, to support the efficiency and effectiveness of business activities. Therefore, herein this paper, when BD is mentioned, both of the two dimensions are encapsulated.

In HEIs, BD can be implemented to design, monitor and support the teaching and learning processes. However, the level and depth of its understanding among faculties in HEIs vary; quite some faculties do not have much apprehension of BD as well as its importance to HE systems, as contended by Griffore (2018) that there is an insufficiency of BD literacy in many HEIs. Thus, Griffore (2018) has clearly highlighted that it is necessary to have substantial and extensive research to investigate the receptivity and perception of BD among HE professionals. This viewpoint can find its support from other researchers (e.g., Daniel, 2015; Chaurasi and Rosin, 2017; Rezaee, et al., 2018; Li and Jiang, 2021). In the same vein, this research will place one of its foci on exploring the understanding of BD concept/connotation and acceptance of BD's importance by academic, administrative and IT staff in HEIs in and associated with the field of logistics and operations management.

2.2 Research on the implementation of BD/its analytics

In recent years, with the increasing awareness of the usefulness of BD and its analytics, more and more HEIs have devoted their efforts to the application of BD/its analytics in their strategic and operational routine educational activities (Li and Jiang, 2021). BD can be applied for such as assisting in designing teaching/research content and processes, and corresponding to the changes of the needs and demands from stakeholders to plan the future programmes/modules suitable for the various career markets and business operations (Baig, et al., 2020; Li and Jiang, 2021).

To date, there has research been conducted on the implementation of BD in HEIs, although the number of them is still not big enough (Li and Jiang, 2021). Meanwhile, the existing research focuses mainly on the aspects of BD in understanding learning patterns of the students and the perspectives where learning takes place; consequently, providing teachers with relevant information to identify, design and conduct activities that can form the effective teaching and assessment processes (Chaurasia, et al. 2018; Daniel, 2015; Griffore, 2018, Baig, et al, 2020; Li and Jiang, 2021). There is a substantial lack of research exploration on how BD and its implementation can assist faculty members in enriching and enhancing their own academic knowledge and competence. Also, in view of that the application of BD in HEIs is still at an early stage, alongside the relatively scant research on its implementation in HE environment (Chaurasia, et al. 2018; Chaurasia and Rosin, 2017; Baig, et al, 2020), as well as that the investigation of BD implementation lacks of a balanced coverage on different countries (Li and Jiang, 2021). In this planned research, the authors have decided to concentrate on the aspect of BD in facilitating academics' knowledge/competence development apropos of the similarity and difference of which between a few representative countries, with a particular focus on logistics and operations management academics, due to that there is not a clear distinguishing on the study of BD impacts between different faculties. The representative countries focused by this research are China, UK and Denmark; they were decided and confirmed through the pilot survey on the experts who expertise in the field of logistics and operations management.

2.3 Research questions to be enquired

Following the aforementioned, the questions to be investigated by this research project include:

- 1) What do the academics/other staff understand about BD and its implementation?"
- 2) Have their institute/faculty/school/department formally applied BD and its analytics in supporting the employees' knowledge and competence development? Why or why not?

- a) If the answer is yes, what technologies/techniques have been used in effecting BD/its analytics implementation?
- b) If the answer is no, will the academics be suggesting their institute to apply BD/its analytics or will the academics act by themselves to use BD/its analytics to support the academic work and why? And by which means to apply BD/its analytics?
- 3) In view of the existence of barriers and drivers to any new initiatives, what are the drivers as well as barriers with regard to the implementation of BD/its analytics?

3. METHODOLOGY EMPLOYED BY THIS RESEARCH

This research will be applying multiple case study strategy to obtain in-depth and thorough understanding on BD/its analytics implementation in HE context. As an effective means to study real world phenomenon, case study strategy can provide comprehensive insights to answer why and how questions as well as to clarify ambiguous content of new theories (Yin, 2018). Following the replication logic, a multiple case study with cases from HEIs in different countries can provide an interesting and holistic view of BD/analytics implementation in HE sectors. Along the same line, the research participants in each case institutes will be selected from faculty members in the field of logistics and operations management, as well as those from the relevant supportive functions (e.g. IT department). This kind of informants from multiple perspectives can strengthen the coverage and representativeness of findings from the research.

The research project as a whole is planned to be completed through two stages.

Stage 1, firstly, an extensive literature review is conducted focusing on BD/analytics implementation in HEIs, to distill a background knowledge foundation for research questions' development as well as their analysis at later stage. Particularly, the authors endeavor in focusing on BD in the faculty field of logistics and operations management and its facilitation on the academics' knowledge/competence enhancement and improvement. Then the research questions were primarily developed based on the learning and inspiration from the literature and further attested by a pilot expert survey process, which was also used to decide the suitable countries where the case institutes will be selected from. The outcome of this first stage research was summarized in this paper.

Stage 2, following the outcome from the previous stage, the empirical data will be collected from the participants in the universities in China, UK and Denmark. The concrete data collection method is semi-structured interview, which is in accordance with the type of questions to be explored. The findings from Stage 2 will be reported in a separate paper when its planned research content has been completed.

4. OUTCOME FROM THE FIRST STAGE

Following the research plan, after the investigation questions have been developed by one of the authors based on literature review, pilot survey among four field experts was conducted to scrutinize the research questions, as well as to attest the meaningfulness of the research project itself and decide the representative countries where case HEIs to be selected.

The pilot expert survey has been undertaken among the academic professionals (the authors) in the field of and relevant to logistics and operations management. They all have more than five years' experience working in HEIs and also are familiar with the IT tools and systems used for information and data management for daily educational processes and activities.

Through pondering and exposition, the experts confirmed the list of the research questions as articulated in Section 2.3. The following table illustrates the average score of the respective questions in view of their appropriateness. The assessment rating follows a five-point scale from 5 - Very appropriate to 1 - Very inappropriate.

Research question no.	Assessment rating
1	4.7
2a	4.3
2b	4.8
3	4.3

Table 1. Assessment ratings on the appropriateness of the research questions

From Table 1, one can clearly notice that in general, the research questions' appropriateness has been attested.

5. FURTHER RESEARCH ACTIVITIES

Through enquiring the research questions developed from the preliminary stage of the research, the second stage research will be carried out soon to bring in more substantial and in-depth understandings of the issues relevant to the implementation of BD/its analytics. The findings from the second stage will be contributing to both theoretical understanding and practical guidance and/or reference on BD's effective and efficient support to HE academics in enriching their knowledge and enhancing their capability to fulfil their roles more excellently, ultimately leading to the enhanced learning experience of the students.

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JOB SATISFACTION, SUPPLY CHAIN AGILITY AND FIRM SUSTAINABILITY POST COVID-19

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1. Introduction

The COVID-19 pandemic has significantly impacted businesses and supply chains worldwide (Wang, 2023). The pandemic has highlighted the importance of supply chain agility and its impact on firm sustainability (Wang et al., 2023a, Wang and Wang, 2023). Companies must embrace supply chain agility to build a resilient supply chain post-COVID-19 (Flynn et al., 2021). In addition, firms have been struggling to survive in this challenging environment. In response, firms have had to find ways to manage their operations, stay alive, create competitive advantages, and maintain their sustainability post-COVID-19 (Flynn et al., 2021). It is crucial to explore strategies that can enhance their sustainability and agility.

Employees are critical for sustainable supply chain operations (Jiang et al., 2009). The COVID-19 pandemic has not only resulted in numerous supply chain disruptions (Wang, 2023) but has also brought attention to the well-being of human workers. Some firms have struggled to adapt to the challenges posed by the pandemic, including disruptions to supply chains, digitalisation, changes in consumer demand, and economic uncertainty. Supply chain agility has become increasingly important in the wake of the COVID-19 pandemic (Wang and Wang, 2023). Firms with agile supply chains are better able to respond to sudden changes in demand and supply and are more resilient in the face of future disruptions (Braunscheidel and Suresh, 2009). Sustainable firms are those that can maintain their operations and profitability while mitigating their negative impacts on the environment and society. Sustainability has become an essential consideration for different stakeholders, such as consumers and investors, and firms must prioritize sustainability post-COVID-19. Therefore, firms need to understand how job satisfaction influences supply chain agility and sustainability post-COVID-19.

Although many authors emphasise that employees play a vital role in organisations (Yee et al., 2008, Jiang et al., 2009), research on the impact of employee satisfaction on business operations is relatively scarce. Considering the research gaps, this study aims to explore the relationship between job satisfaction, supply chain agility, and firm sustainability, and how supply chain agility can be leveraged to enhance the sustainability performance of firms in the post-COVID-19 era. Thus, we propose the following research questions:

RQ1: How does job satisfaction affect a firm's sustainability through supply chain agility?

RQ2: How does supply chain agility impact the relationship between job satisfaction influence a firm's sustainability?

Based on the RBV and the social capital theory, to answer these research questions, an empirical study is conducted to investigate the relationship between job satisfaction, supply chain agility, and firm sustainability, and how supply chain agility can affect the relationship between job satisfaction and firm sustainability in the post-COVID-19 era. The empirical study is the first to explore how job satisfaction affects a firm's sustainability through supply chain agility. This study contributes to the existing literature. This provides theoretical implications for the role of employees in achieving supply chain agility and highlights the importance of considering employee job satisfaction in supply chain management. This study provides valuable insights and recommendations for firms to enhance their supply chain agility and sustainability in the post-pandemic world.

2. Theoretical background and hypothesis development

The resource-based view and social capital theory are two important perspectives in the field of management and organizational theory that highlight the strategic significance of resources and social networks, whether tangible or intangible, for organizations. Both theories consider humans as important resources in organisations and human capital is the key to creating value and sustaining competitive advantages. The conceptual framework has been developed in the study (Figure 1).

2.1 Job satisfaction and supply chain agility

Employee job satisfaction has traditionally belonged to the field of organisational psychology (Scarpello and Campbell, 1983, Judge et al., 2001). However, employee attributes are getting more and more attention in operations management (Yee et al., 2008, Ukko et al., 2007). Furthermore, the COVID-19 pandemic has drawn attention to the importance of human capital/staff in the business. Jiang et al. (2009) argue that job dissatisfaction may trigger substantial shortages and delays in the global supply chain owing to supplier labour problems. Jacobs et al. (2016) reveal that employee satisfaction significantly influences supply chain integration. Gölgeci and Kuivalainen (2020) argue that firms' social capital can lead to supply chain resilience.

Supply chain agility refers to a firm's ability to respond quickly and effectively to changes in the market and customer demand (Braunscheidel and Suresh, 2009). Humans are the key to responding to changes, implementing new technologies, and collaborating tasks in supply chain operations (Wang et al., 2020, Locke and Romis, 2007). Job satisfaction can influence the performance of employees in the supply chain (Jiang et al., 2009).

Locke and Romis (2007) argue that organisations must monitor and improve working conditions in global supply chain factories. Jiang et al. (2009) emphasise that workers with negative job attitudes such as job dissatisfaction are likely to perform poorly in supply chain operations, which may cause disruptions to normal operations. Maloni et al. (2017) highlight the importance of job satisfaction in supply chain operations. Based on the prior research, we hypothesised that satisfied workers were more likely to promote supply chain agility. Therefore,

Hypothesis 1. There is a direct and positive relationship between employee job satisfaction and supply chain agility.

2.2 Job satisfaction and firm's sustainability

Human capital is critical for firm performance (Wang et al., 2022, Lamm et al., 2015). Social capital theory suggests that social relationships, networks, and interactions can create valuable resources for organizations, such as trust, information, social norms, and social support, which can be leveraged to create value and achieve competitive advantages (Coleman, 1988, Wang et al., 2023b). Job satisfaction and sustainability are two important concepts that are closely related. For example, Lamm et al. (2015) argue that happy and satisfied employees will actively engage in sustainability behaviours, and this would lead to better organizational sustainability. Lee and Chen (2018) reveal that an organisation's efforts on CSR could enhance the employees' satisfaction and retention intention by fulfilling employee job needs.

If employees are dissatisfied with their job, they may be less motivated to contribute to sustainability efforts. They may be less willing to adopt sustainable practices and may be more likely to leave the organization, leading to turnover costs, labour shortage, supply chain disruption and instability in the workforce (Jiang et al., 2009). Overall, happy employees are more likely to be productive, engaged, and committed to the organisation (Lyubomirsky et al., 2005, Wright and Cropanzano, 2000). This can lead to improved sustainability performance for the organisation. Thus, the following hypothesis is proposed in the study.

Hypothesis 2. There is a direct and positive relationship between job satisfaction and a firm's sustainability.

2.3 Supply chain agility and firm's sustainability

There is growing recognition that supply chain agility and firm sustainability are interconnected (Wang and Wang, 2023). Supply chain agility is viewed as an antecedent to firm sustainability (Wang and Wang, 2023). Supply chain agility enables an agile supply chain, which can quickly respond to changes in customer demand, market trends, and supply chain disruptions (Christopher, 2000, Teece et al., 2016). When it comes to sustainability, an agile supply chain may help to reduce waste, conserve resources, and minimise carbon emissions (Gligor et al., 2015, Wang et al., 2020). By quickly responding to changes in markets, an agile supply chain can also help to eliminate waste, which can lead to better financial performance (Gligor et al., 2015). Furthermore, an agile supply chain can help to build resilience in the face of sustainability-related risks (Teece et al., 2016), such as natural disasters, climate change, and social disruptions. By being able to quickly respond to these risks, organizations can mitigate the impact on their operations, supply chain partners, and the environment (Wang et al., 2018). Thus, the following hypothesis is proposed:

Hypothesis 3. There is a direct and positive relationship between supply chain agility and a firm's sustainability.

2.4 Role of supply chain agility

Supply chain agility plays a vital role in linking job satisfaction to sustainability performance in organizations. In literature, agility as a concept was introduced as a mechanism for companies to cope with change (Geyi et al., 2020, Gligor et al., 2015). In this study, we argue that supply chain agility means not only quick response to suppliers and customers but also the quick resolution of problems, reconfiguration of business processes to adapt to changes and implementation of continuous improvement post-COVID-19. Research has shown that job satisfaction is positively related to performance in organisations (Judge et al., 2001, Wright et al., 2007). When employees are satisfied with their job, they are more likely to be committed to the organization, be productive, and take ownership of their work (Locke, 1969, Lyubomirsky et al., 2005, Maloni et al., 2017, Wright and Cropanzano, 2000). This may lead to improved sustainability performance (Lamm et al., 2015).

Meanwhile, an agile supply chain can help to improve sustainability performance by enabling organizations to work with suppliers and quickly respond to changes in customer demand, supply chain disruptions, and sustainability-related risks. As discussed before, an agile supply chain can also help to promote sustainability by reducing waste, conserving resources, and minimising carbon emissions (Gligor et al., 2015, Wang et al., 2020). By being able to quickly respond to changes, resolve problems, reconfigure operations processes, and adopt sustainable practices, supply chain agility can explain the positive effect of job satisfaction on sustainability performance. However, current literature offers little guidance on how supply chain agility moderates the relationship between job satisfaction and performance. Supply chain agility has been considered as an important strategy to build resilience, and address uncertainties post-COVID-19 (Wang and Wang, 2023, Flynn et al., 2021, Patel and Sambasivan, 2022). Therefore, it is plausible that supply chain agility mediates and moderates the relationship between job satisfaction and sustainability performance in organizations. Thus, the following hypotheses are proposed:

Hypothesis 4. Supply chain agility mediates the relationship between job satisfaction and a firm's sustainability.

Hypothesis 5. Supply chain agility moderates the relationship between job satisfaction and a firm's sustainability.

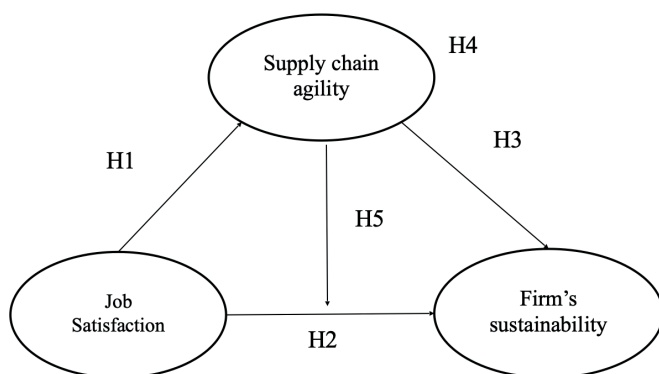


Figure 1. Conceptual framework

3. Research methodology

We have collected primary data through a web-based questionnaire in 2022 across the UAE's seven emirates: Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain, Ras Al Khaimah and Fujairah. A total of 271 usable responses were received for a response rate of 20%. Non-response bias and common method variance were tested in the study. non-response bias, they are not a significant problem in our study.

Job satisfaction is a single-item measure. The single-item self-rating scales have been long used in many prior studies, the single item is more economical for large-scale surveys and offers many advantages (Abdel-Khalek, 2006, Scarpello and Campbell, 1983). Scarpello and Campbell (1983) suggest that overall job satisfaction may be a more inclusive measure of overall job satisfaction than the summation of many facet responses. The supply chain agility scale was adopted from previous studies (Wang et al., 2023a). The firm's sustainability performance measures were mainly adopted from prior research (Wang and Wang, 2023). We used both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to verify the measurement models in our study. The results demonstrate the reliability and validity of the scale (see Table 1).

4. Data analysis

The KMO measure of sampling adequacy is 0.93. Bartlett's test of sphericity is another statistical test used to assess the suitability of data for factor analysis. our results ($p < 0.001$) indicate that our data are suitable for factor analysis in this study. Exploratory Factor analysis (EFA) is a statistical technique that is used to identify underlying factors that explain patterns of correlation among a set of observed variables (Fabrigar, 2012). Principal components analysis with a varimax rotation method was applied to assess the common factor, and Kaiser's criterion - Eigenvalues greater than 1.0 was used to determine the number of factors (Fabrigar, 2012). We used the partial least squares structural equation modelling (PLS-SEM) technique to conduct data analysis.

In reflective measurement model assessment, factor loadings should be 0.70 or higher. A composite reliability (CR) value of at least 0.70 is generally considered acceptable for composite measures. Internal consistency reliability also can be measured by Cronbach's alpha, values between 0.70 and 0.90 range from "satisfactory to good." (Hair et al., 2019).

Convergent validity examines whether two different methods of measuring the same construct produce similar results. An acceptable average variance extracted (AVE) is 0.50 or higher. Discriminant validity examines whether two measures of different constructs produce dissimilar results. To evaluate the discriminant validity of the reflective measures in a structural model, it is recommended to compare each construct's average variance extracted (AVE) with the squared correlation between that construct and all other reflectively measured constructs. This squared correlation serves as an estimate of the amount of shared variance between the constructs. The AVE for each construct should be greater than the shared variance that the construct has with all other constructs in the model.

Nomological validity is used to test the single-item measure (Cheah et al., 2018, Abdel-Khalek, 2006). Nomological validity is a type of construct validity that refers to the extent to which a measure of a particular construct is related to other measures or constructs in a manner that is consistent with theoretical expectations or hypotheses. Our results affirm that the correlations among job satisfaction, customer satisfaction and profitability are highly significant and positive. This indicates the nomological validity of the single-item measure.

Construct validity was demonstrated by the adequacy of the model's fit and both convergent validity and discriminant validity. A PLS-SEM model is considered to be satisfactory if the Bentler-Bonett Normed Fit Index (NFI) is greater than 0.90, and the root mean square error of approximation (RMSEA) is less than 0.08 (Hair et al., 2019). Our results show that $NFI = 0.88$, and $SRMR = 0.063$. Our PLS-SEM model fit is satisfactory.

Table 1 Measurement reliability and validity test

Scale items	Standardised factor loadings	Cronbach's alpha	CR	AVE
Supply Chain Agility (SCA)				
1. Our company is capable of Joint planning with suppliers in purchasing, production and logistics.	0.82	0.93	0.94	0.75
2. Our company is capable of responding to suppliers' and customer's requests at a fast speed	0.90			
3. Our company is capable of adjusting production/service capacity/capability	0.86			
4. When an unexpected situation arises, our company and the supplier would solve problems adequately.	0.87			
5. When an unexpected situation arises, our company is capable of reconfiguring operations process to adapt to the changes	0.88			
6. When a disagreement arises in the transaction process, our company and the supplier would re-evaluate the ongoing situation to achieve a mutual-satisfied solution.	0.86			

Firm's sustainability (FS)				
1. Our company has a strong profitability	0.78	0.85	0.89	0.63
2. Our company has a high market share	0.77			
3. Our company has a reputation in the industry	0.82			
4. Our company is a socially responsible business	0.84			
5. Our company is an environmentally friendly business	0.77			
Job Satisfaction (JS)				

Our company has a high level of employee job satisfaction*	1	1	1	1

Note: *single-item measure

Table 2 Correlation matrix and descriptive statistics for constructs

	Mean	SD	JS	SCA	FS
JS	5.06	1.61	1		
SCA	5.52	0.07	0.649	0.866	
FS	5.63	0.83	0.659	0.711	0.795

Note: The square root of the construct's AVE is provided along the diagonal.

4.3 Structural model

PLS-SEM was used to estimate the research model in the study. Our results already showed a satisfactory model fit. Then we investigate the relationship between job satisfaction, supply chain agility, and a firm's sustainability to test research hypotheses. Table 5 illustrates the results of the hypothesis test in this study. Hypothesis 1 is supported ($\beta=0.65$, $t=14.68$, $p<0.001$), indicating a direct and positive relationship between job satisfaction and supply chain agility. Our results support Hypothesis 2 ($\beta=0.35$, $t=6.25$, $p<0.001$), suggesting a direct and positive relationship between job satisfaction and a firm's sustainability. Not surprisingly, Hypothesis 3 is confirmed ($\beta=0.47$, $t=7.61$, $p<0.001$), this supports a direct and positive relationship between supply chain agility and a firm's sustainability. The results are consistent with previous studies (Gligor et al., 2015, Wang and Wang, 2023, Wright et al., 2007).

4.4 Mediation and moderation analysis

We used a bootstrap method (with $n = 1500$ bootstrap resamples) to examine whether supply chain agility mediates and/or moderates the relationship between job satisfaction and a firm's sustainability (Preacher and Hayes, 2008). Testing mediating effects was preferred to be conducted using the bootstrapping method (Gligor et al., 2015). The mediating effect of supply chain agility in the relationship between job satisfaction and a firm's sustainability was statistically significant at $p < 0.001$ with 95 per cent CI = 0.220–0.413. H4 is supported in the study. To test moderation effects, we find that H5 ($\beta=-0.078$, $t=2.10$, $p<0.05$) with 95 per cent CI = -0.151–0.005, unfortunately, we must reject the moderation hypothesis, because the confidence interval includes zero, this hypothesis (H5) is not supported in our study.

Table 4. Results of a hypothesis test

Hypothesis	Path	Path coefficient	t value	P value	Notes
H1	JS→ SCA	0.65	14.68	<0.001	Supported
H2	JS→FS	0.35	6.25	<0.001	Supported
H3	SCA→ FS	0.47	7.61	<0.001	Supported
H4	JS→ SCA→ FS	0.31	5.84	<0.001	Supported
H5	JS*SCA→FS	-0.078	2.10	<0.05	Not supported

5. Discussion and conclusion

This is the first study that suggests that job satisfaction is a crucial antecedent to achieving supply chain agility and thus highlights the need for organizations to prioritise employee well-being and satisfaction. Our empirical results demonstrate that job satisfaction, supply chain agility and a firm's sustainability are closely linked, and both job satisfaction and supply chain agility are important factors in the success and sustainability of an organization. By promoting job satisfaction and building an agile supply chain, organizations can improve their efficiency, effectiveness, and flexibility in the supply chain, leading to improved sustainability and success. This may address the workforce shortage, and high labour turnover (Jiang et al., 2009).

According to the two theories RBV and social capital theory, the research provides theoretical implications for the role of employees in achieving sustainability through supply chain agility and highlights the importance of considering employees and their social capital in sustainability transformation efforts. From an RBV perspective, Priem and Butler (2001) argue that RBV falls short in addressing inquiries about how to acquire resources. Our study shows that firms may develop a sustainable competitive advantage by investing in human capital, which may enhance supply chain agility, leading to improved sustainability performance.

From a social capital theory perspective, our findings suggest that employees can be viewed as valuable social assets that contribute to the development of trust, collaboration, and knowledge-sharing within a firm's supply chain networks. Satisfied employees are more likely to have positive attitudes and behaviours towards their work and colleagues, which can create a culture of trust, mutual respect, and collaboration within a company. Working closely with stakeholders to achieve better performance and create value (Wang et al., 2023b). Overall, both theories suggest that firms should invest in their employees and view them as valuable resources and social assets that can contribute to their sustainability goals. We can argue that this human capital investment can lead to enhanced supply chain agility, improved sustainability performance, and a sustainable competitive advantage.

The study provides managerial implications. First, our study highlights the need for managers to prioritise the satisfaction and well-being of their employees post-COVID-19. Numerous studies have already demonstrated the benefits of having happy and satisfied employees in organisations (Locke and Romis, 2007, Wright et al., 2007). Second, this study reveals that job satisfaction and sustainability are closely linked, and managers should strive to create a work environment that promotes both environmental and social sustainability to foster long-term job satisfaction and retention of their employees. Third, the post-pandemic era is characterized by a high degree of uncertainty, such as Brexit, the Russian invasion of Ukraine, China–United States trade war, extreme weather, natural disaster, etc. It has been suggested that firms operating in highly uncertain environments should adopt agile strategies (Christopher, 2000). Managers must recognise the significant role of their employees in building resilience post-COVID-19. Our study suggests that agile strategies can serve as a crucial intermediary between job satisfaction and sustainability performance in organizations.

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UNDERSTANDING CONSUMER BUYING BEHAVIOUR IN TIMES OF PANIC: DEVELOPMENT OF A RELATIONSHIP FRAMEWORK OF INFLUENCING FACTORS

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Introduction

Global events over the past number of years have led to major supply chain disruptions. From the Russia-Ukraine war to vessels getting stuck in the Suez Canal to abnormal weather patterns, and above all, the pandemic. The impact of these events on supply chains can often be seen in several risks and uncertainties from the supply side, but also from the demand side, such as product shortages, longer and unpredictable lead times, changes in consumer behaviour and demand patterns (Ozdemir, et al., 2022).

The Covid-19 pandemic, when studied as a disruption, is quite unique in nature in terms of the reach of its effect, where more than 90 countries were impacted (Arafat, et al., 2021). Also, in terms of the global response where entire cities were put into lockdown, shut down of airports and seaports, and restrictions imposed on international travel. This not only created scarcity in terms of the availability of basic products and services, but also created scarcity in terms of the time when these products and services could be purchased or accessed in person.

It is well documented in the literature that consumer behaviour as a response to supply chain disruptions is expressed in the form of panic buying (Yuen, et al., 2020). Another commonly seen behaviour in times of crises is a shift in spend patterns from luxury items that would be considered wants, to more basic items, i.e., needs. Accordingly, the FMCG sector, which covers many of these basic needs, is significantly affected by these disruptions (Li, et al., 2021).

Panic buying is usually defined as an emotional decision, with specific emotions, notably anxiety and fear, acting as a response to the perceived scarcity and/or unaffordability of the product or service (Arafat, et al., 2021; Li, et al., 2021). The resulting effect is an inflated cycle of amplified demand leading to product hoarding and panic buying, which can in turn lead to the actual shortage or limit the availability of products or services, feeding into the perceived scarcity and increasing the overall fear, anxiety, and emotional response of needing to buy more.



Figure 1: The Panic Buying Cycle

This paper therefore considers the Covid-19 pandemic as a unique learning opportunity to better understand consumer behaviour in times of panic. The paper aims to critically examine and identify the causal factors that influenced consumer buying behaviour and changing demand patterns during the pandemic, specifically within the FMCG sector. The paper will then develop a conceptual framework that models the relationship between the factors with a view to better understand how supply chains can better address panic buying.

Literature Review

A critical review was conducted that focused on consumer behaviour in times of crises, specifically within the FMCG sector (Grant and Booth, 2009). The main keywords used in the literature search were (consumer behaviour, supply chain disruptions, FMCG, Covid-19). There was no specific database selected for the search and a snowball method was applied to find relevant articles. This is one of the limitations of this study, where the model and findings could be further expanded through the use of a more systematic or structured approach to developing the literature review.

With the exception of a number of papers that explained the theory of panic buying and consumer behaviour, the majority of the papers included in the review did specifically refer to the Covid-19 pandemic. The purpose of the review was to critically examine previous literature with a view to identifying the main factors affecting panic buying.

Table 1 below provides a summary of the findings. The left most column introduces the main factor, while the middle column provides a justification as to how that factor affects or leads to panic buying.

Table 1: Factors Affecting Panic Buying

Government influence	Government's product regulation tools during Covid-19. Lockdown and curfews imposed limiting access to products and services	Sheu and Kuo, (2020)
	The government's peer sanctions against hoarding during Covid-19.	
	Economic instruments used by the government such as subsidies or donations in regulating products during Covid-19.	
Commercial impact	During Covid-19, shops introduced purchase quotas limiting the number of units any one consumer could purchase.	Prentice et al., (2021)
	Increase in the prices of products in the shops during covid-19.	
	Shorter allotted shopping times to control the number of shoppers at any given time.	
Social influence	Media portrays public fears of supply shortages during covid-19 over product price fluctuations.	Sheu and Kuo, (2020)
	The media portrayed the public's frequent panic buying of products during covid-19.	
	The media further focused on shortages and missing commodities feeding consumer's perceived scarcity.	
Social norms	Colleagues, neighbours, family members, classmates' behaviour of panic buying created a feeling of increased perception of scarcity, fear and anxiety.	Gong et al.(2019)

Government influence, commercial impact, social influence and social norms could all be seen to have a direct impact on both consumers' emotions in terms of fear and anxiety, and also on consumers' perceived scarcity of products in terms of the limits on quantity they can purchase and time when they can physically access the stores. Furthermore, it can be seen that perceived scarcity in itself also had an impact on increased fear and anxiety. However, both emotions and the perception of scarcity can be identified within the literature as the level 1 factors behind panic buying, with the four other factors categorised as level 2 factors. Level 1 factors can also be considered internal factors that are subjective, and the degree of the effect can be different from one individual to another. Level 2 factors are external factors that can either have a positive or negative effect on level 1 and therefore either lead to an increase or decrease in panic buying. This relationship is used as the foundation for developing the conceptual framework presented in Figure 1.

Conceptual Framework

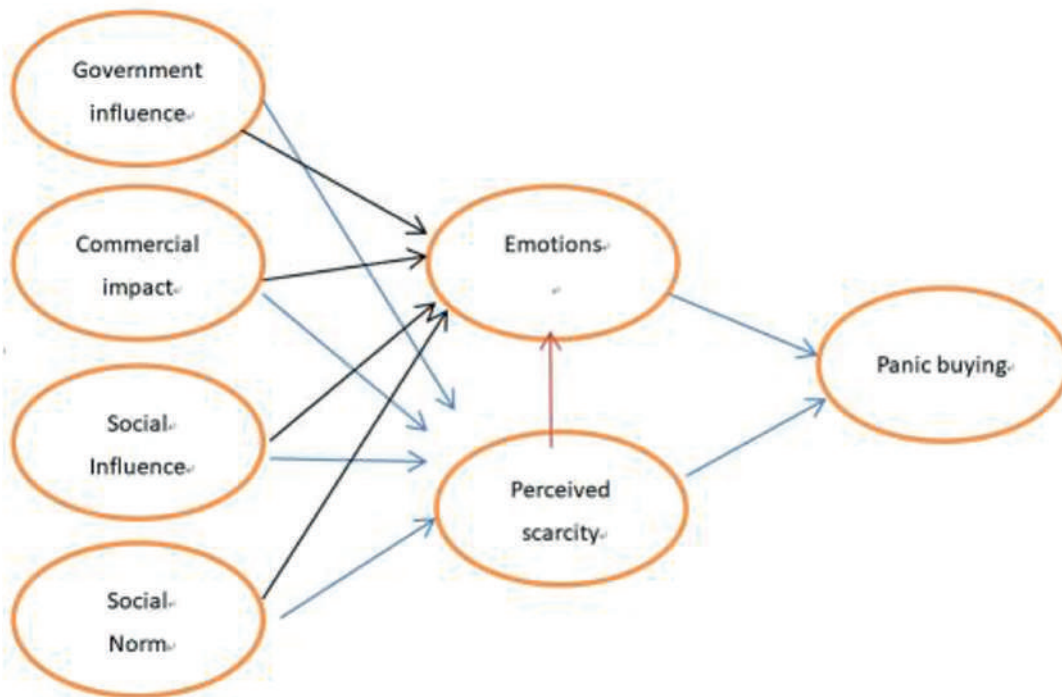


Figure 1: Conceptual relationship framework for panic buying

The framework was modeled on the stimulus-organism-response (SOR) model (Mehrabian and Russel, 1974). The model builds a relationship between stimuli, which are the four main identified external factors; to an organism, which for this study is the cognition and emotion of people in terms of fear, anxiety, and perceived scarcity; to a response, which for this study is that act of panic buying.

Government Influence on Emotions and Perceived Scarcity

Depending on the stage of each country in the face of the epidemic, governments in each country have adopted different policies and instruments. Some see it as an important channel to control the spread of the epidemic; others see it as a means to instill social trust in the population (Yuen, Wang, Ma and Li, 2020). During an outbreak, the government has a crucial role to play in providing relief, recovery, maintaining order and providing services to the population. The public's trust towards the government influences its legitimacy and compliance and demonstrates the government's willingness to do all it can to manage and control the spread of the disease (Yuen, Wang, Ma and Li, 2020). Trust plays a key role as a moderator of public sentiment. With trust, people's emotions can be effectively controlled, and the credibility of government communication can be increased. A high level of government trust suggests that people will adhere strictly to government preparedness measures and that individuals will behave more collegially and considerately, hoarding only enough supplies to share with their families. Low levels of government trust, however, can lead to a prevalence of individualism, fearing that others will buy more than their share, or hoarding too much for them and leaving nothing for others, which creates a change in perception and has a negative impact on mood. A lack of trust, on the other hand, fosters restlessness in society, thus increasing the fear and anxiety of people. In order to gain the trust of the people, the governments in general have adopted various strategies to provide relief and recovery to maintain economic order. Meanwhile, as the epidemic worsened, governments also increased restrictions on people travelling. The bans included no more than five people at a party event and social distances. When travelling outside the country, a medical testing or quarantine is needed while people travelling abroad for pleasure trips. This change has caused residents to feel a health crisis, which has led to feelings of panic and anxiety. In addition to this, the government's adoption of precautionary measures based on a blockade may interrupt the supply of essential goods depending on the severity of the epidemic, which increases the risk of people's perception of supply disruption and stimulates the internal perception of scarcity.

Commercial Influence on Emotions and Perceived Scarcity

In addition to safeguards from the government, major manufacturers and retailers have responded with counter-hoarding or panic measures (Prentice et al., 2021). In Australia, for example, large supermarkets such as Aldi and Woolworth's will inform buyers in advance that they will ensure adequate supplies of essential goods during the epidemic. At the same time, some supermarkets may intervene in panic buying by raising prices or limiting the number of essential items that can be purchased. Offline retail supermarkets in China have also ensured adequate supplies internally and have been ordering remotely for orders placed on social chat software such as WeChat during the epidemic lockdown. Online shopping e-commerce platforms such as JD.com have maintained non-contact delivery for consumers. Retail shops in Vietnam have also urged consumers not to stock up on essential items such as food in large quantities, indicating that adequate supplies of consumer goods will be ensured even during the blockade. The supply guarantee by major retailers and manufacturers stabilizes consumer purchasing sentiment and reduces perceived scarcity.

Social Influence on Emotions and Perceived Scarcity

Social influence has been categorized by Smith, Louis and Schultz (2011) into a number of different forms and is mainly felt in processes such as conformity, pressure, leadership, persuasion and social power change. Social influence can be divided into non-coercive and coercive influences, where the non-coercive includes information exchange or advice, while the coercive is reflected in how an individual's behavior is constrained by a third party (Yuen, Tan, Wong and Wang, 2022). The social influences studied in this paper are mostly in the form of non-coercive social media. With today's technology, social media has enabled the sharing of information on a global scale. With the use of smartphones, computers and other electronic devices, people's perception of information is also time sensitive (Hornmoen and Backholm, 2018). With social influence there is also an expected level of trust depending on the source of the information linked to whether it is from credible news sources or through unstructured social media platforms which feeds more into the social norms aspect. The more trusted the source of the information is the higher impact it will have on consumers' emotions and perceived scarcity. This also connects to government influence in certain cases where there is a heavy presence in state owned media. The level of trust consumers have in the government will be a factor in their trust of information being shared across state owned media in comparison to private owned media.

Social Norms Influence on Emotions and Perceived Scarcity

As defined by Cialdini and Goldstein (2004), social norms are rules and standards that are commonly accepted by members of a social group and are codes of conduct that are not bound by laws or regulations. In order to conform to this group, people's behaviour is often determined by the opinions, attitudes or beliefs of the larger group. Herd mentality is the tendency to change behaviour in response to pressure. Single factor analysis found that the results of the performance of the degree of influence by those around them were very clear. The herd mentality makes the individual's behaviour and thoughts converge with the group, making the individual also lack independent thinking. Panic buying is a misperception of social norms that people have, and in realising that peers engage in panic buying practices, the individual's decision receives a normative misperception and blind following occurs. Individuals tend to conform to social norms shared by their friends and colleagues in order to seek a sense of belonging and social identity, the behaviours and perceptions of other members of society can influence them. So when people do not have enough information to assess the actual situation, they learn from the behaviour of others and use it as a source of information. Family and friends are part of the social network and are part of the first thing that consumers consider when making decisions in the absence of relevant information. In this study, social norms are defined as the degree of acceptance of hoarding by members of the community around the individual. Under the influence of covid-19, a new social norm has emerged, namely hoarding purchases (Li et al., 2021). This behavioral change can be interpreted as a perceived scarcity of products in short supply and rising prices, thus conveying the message that household goods are not available to support normal life. Ultimately, members of society become more accepting of hoarding, and people's perception of product scarcity increases, resulting in anxiety and concern about not having access to products.

Conclusion and Recommendations

The main purpose of this paper has been to take the Covid-19 pandemic as a learning opportunity to identify the main factors that impacted consumer panic buying behaviour during the crisis. The paper has presented a conceptual framework model based on the SOR framework that has presented four external factors (identified as the stimulus) and two internal factors (identified as the organism) and developed the relationships across the factors to better explain the response, which is the panic buying behaviour.

This paper presented panic buying as a consumer behaviour in the form of a loop where one end of the loop feeds into the other causing the effects from emotions and perceived scarcity to be further amplified and leading to more panic buying. Therefore, a deeper understanding of the factors and interrelationships between the factors can be used to better shape how supply chains engage with consumers and other stakeholders in developing policies on communication and information sharing with the wider populace to mitigate the effects of panic buying as a consumer response to crises.

Through the conceptual framework presented different governmental policies and how different countries responded to the pandemic can be studied in terms of the effectiveness of these policies in reducing overall fear, anxiety, and perceived scarcity.

The model also presents an opportunity to measure the correlation between the different factors and their overall effect on panic buying. This can be used to better direct efforts in managing and mitigating the effects of panic buying.

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UNCOVERING BLOCKCHAIN TECHNOLOGY IN ENHANCING FOOD SUPPLY CHAIN MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

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1. Introduction

Globalisation of the food industry has extensively reshaped the food supply chain (FSC), as more people, products, and information move between countries (Behnke and Janssen, 2020). Consequently, consumers are able to access international food products at their local market (Li et al., 2021). The growth of food options has altered consumer purchasing behaviour, on the other hand, rendered the operation of FSC to be more challenging (Behnke and Janssen, 2020). Adulteration of food is a major cause of concern due to the current lack of transparency in the production process (Astill et al., 2019). Currently, there are serious problems associated with non-transparent FSCs. The current pitfalls of food production include delayed response times, underdiagnosis of foodborne illnesses (Astill et al., 2019), lack of transparency leads to food counterfeiting and recalls (Li et al., 2021), and FSC practitioners may also gain unethical advantages from supply chain practices (Friedman and Ormiston, 2022).

Food authenticity and labelling are also emerging as increasingly prominent factors for consumers, businesses, and regulatory agencies. Changes in customer attitudes and strengthened food laws and regulations have been significant factors influencing enterprises to ensure the quality, safety, sustainability, and effectiveness of food products and services (Kumar et al., 2022). Identification of contamination sources is a time-consuming process. In the event of a food contamination outbreak, it takes considerable time to determine the source of the contamination (Dong et al., 2021). The modern FSC is highly centralised, resulting in a loss of trust and information asymmetry as a result of the control of information flow being excessively dominated by central authorities. In addition to divulging information to enhance their brand image, companies can also conceal information, so that customers only know what food companies and governments want them to be aware of (Duan et al., 2020). Taking these factors into account, the FSC is severely hampered in its ability to function effectively, and a technological solution has become urgently necessary.

The implementation of blockchain technology has been shown to enhance the transparency and traceability of supply chains (Treiblmaier and Garaus, 2022). The use of blockchain technology can facilitate seamless performance improvements in key supply chain management processes while integrating immutability and transparency. A blockchain solution provides visibility that assists decision making by providing stakeholders with timely, accurate, and reliable information while reducing the number of data sources that contribute to decision making (Rogerson and Parry, 2020). Through the implementation of Blockchain technology (BCT), FSCs can optimise the management and transparency of their products by tracing inventories throughout the supply chain (Kayikci et al., 2020). Companies can utilise Blockchain technology in order to collect trustworthy information about shelf-lives and historical data of products; thus, they can arrange to store and transport products according to these data, ensuring food quality and safety (Vu et al., 2021).

Current studies are mostly comprehensive, but lacking taxonomies and frameworks to demonstrate research outcomes and generate more insightful concepts (Li et al., 2021; Vu et al., 2021). A number of research concentrates on only one of the functionalities blockchain can provide for the FSC (Dal Mas et al., 2023; Feng et al., 2020; Kamble et al., 2020; Rana et al., 2021). As a result of BCT development, it is regrettable that some studies have become less insightful when examining BCT adoption in the FSC (Duan et al., 2020; Kayikci et al., 2020). In the majority of literature on blockchain, the benefits and challenges are explored, but adoption barriers and implementation performances are not acknowledged. Therefore, this study investigates the potential for removing adoption barriers in the current context of blockchain implementation and identifies potential implementation performance outcomes. Therefore, this study aims to provide a comprehensive analysis of the current blockchain applications in the FSC and how they are integrated with other technologies. In order to develop such an analysis, a research question is developed as: how could the integration of blockchain technology enhance the management of the FSC?

2. Methodology

In order to answer the research question, a systematic literature review (SLR) approach is employed. SLR is considered a robust methodology for critically reviewing management research literature (Tranfield et al., 2003). In addition to presenting the current applications of BCT, this study will examine potential impediments and performance enhancements in managing FSCs. In addition, BCT is discussed for its significance in addressing the adoption process within contemporary FSCs. In this study, Durach et al. (2017) and Tranfield et al. (2003) propose a five-phase SLR process for the production of a SLR study specifically designed for SCM, which consists of (1) Identification of primary study elements; (2) Baseline sampling; (3) Synthesis sampling; (4) Data extraction; and (5) Reporting and dissemination.

The systematic literature review method we applied is illustrated in Figure 1. Following the research protocol, we examined titles, abstracts, and keywords of three search engines using the research strings. Since blockchain adoption has only been researched in FSC management since 2016, the publication year has been set to 2016-2023 with research strings “(blockchain OR block-chain) AND (food AND supply AND chain OR agriculture)”. The research output of 2094 papers from three databases. We then followed the inclusion and exclusion criteria (Only journal articles examining the use of blockchains to enhance FSC management with managerial perspectives will be considered, whereas articles examining blockchains in other industries with scientific perspectives will be excluded) to further refine the selection of literature. In order to identify relevant articles, duplicates and irrelevant documents were removed, and additional screening of articles was conducted. Upon matching the research theme: blockchain functionalities, impediments, and potential constraints in FSC with the high-quality papers obtained through snowballing, a total of 46 papers were identified.

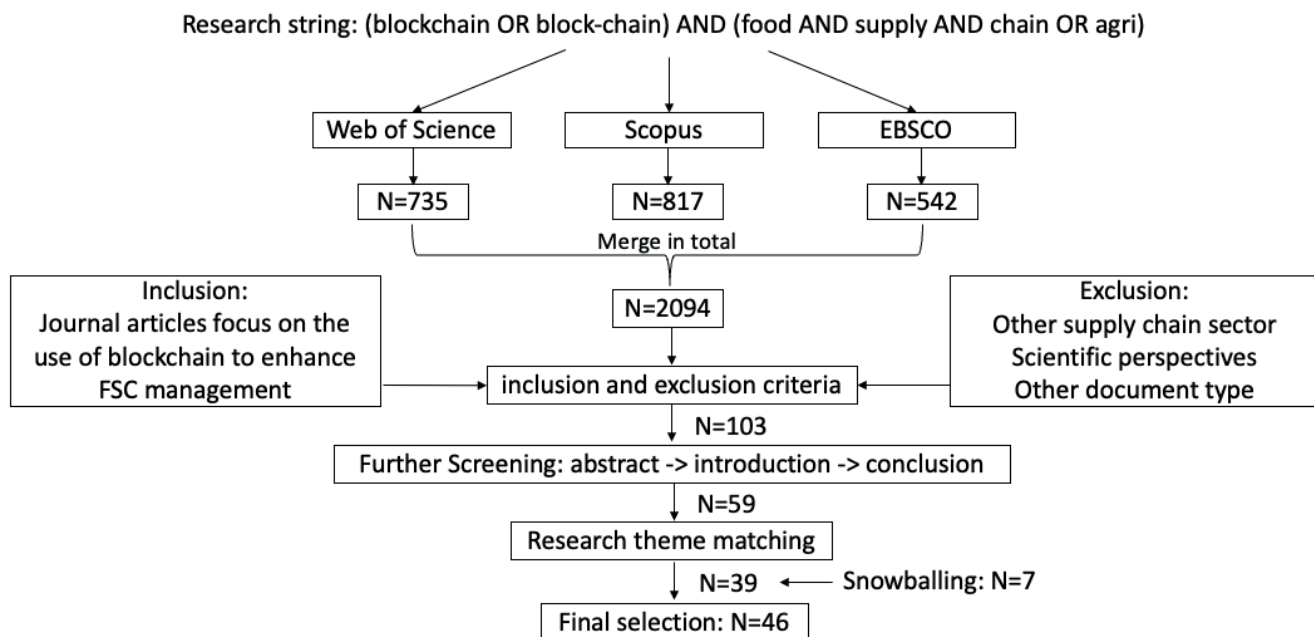


Figure 1. Literature selection process

3. Thematic analysis

This section contains the current findings conducted by thematic analysis. A thematic analysis is commonly used in qualitative research to extract data, analyse literature data, and generate a greater sense of connection with the contents, identify patterns within the articles, and gain a more comprehensive understanding of the content (Williamson et al., 2018). The themes are divided into two categories: Blockchain technology functionalities in FSC management as well as Blockchain potential impediments in FSC management. In order to provide a more comprehensive overview of the findings, the BCT integration framework and the Technical, Organizational and Environmental (TOE) framework are adopted.

3.1 Blockchain technology functionalities in food supply chain

Based on finding and coded themes, blockchain functionalities in FSC management are formatted into four predominant subjects.

Table 1: Blockchain functionalities in food supply chain

Functionalities	Sub-functionalities
Transparency (T)	Trust building (T1): The BCT blockchain ensures FSC information is visible from farm to fork, as well as shipping, packaging and storage information. BCT enables the consolidation of solid relationships with key FSC stakeholders, including suppliers and key customers (Silvestri et al., 2023).
	Risk management (T2): FSCs incorporate BCT to conduct backward and forward follow-ups to identify the source of contaminated products, as it ensures timely, accurate, and reliable information. By locating the contaminated source and prompt response, a massive outbreak of foodborne illness can be avoided. Furthermore, due to information transparency, food fraud and corruption can also be eradicated, including counterfeiting, mislabeling, etc. (Friedman and Ormiston, 2022; Garaus and Treiblmaier, 2021).
	Decision making (T3): Through BCT, stakeholders can see timely, accurate information, while reducing the number of data sources that create decision points. BCT reduces decision risk and facilitates supply chain action. Firms can reconfigure their supply chains to create strategic value, which also improves overall decision-making process (Rogerson and Parry, 2020).
Integration (I)	Production control (I1): All actors in the FSC can be securely connected with blockchain, eliminating food adulteration, ensuring high resolution of food safety issues, improving quality management, and reducing social chaos caused by uncoordinated issues, thereby increasing production safety (Dutta et al., 2020).
	Fairness improvement (I2): Small businesses can address inequalities with blockchain as a platform to share information. Consumers can integrate with first mile insight, ensuring supply chain workers are treated equally. With the “tipping the farmer” function, FSC customers can contribute to the fairness of working conditions through the blockchain infrastructure. It can also be beneficial to organisations like social enterprises, non-profits, fair trade agencies, etc., as it ensures fair supply chain practices and equal value distributions (Friedman and Ormiston, 2022).
Performance (P)	Operational efficiency (P1): Better logistic management helps alleviate overstocking and understocking, as well as reduce transportation costs within the FSC. Furthermore, BCT provides distributors with secure shipping information so they can optimise routing planning and increase transport efficiency. All transaction histories may be audited (Li et al., 2021; Mangla et al., 2022).
	Procedure simplification (P2): The elimination of intermediaries and in-between traders (trading from one FSC stakeholder to another) reduces FSC operations costs. By identifying outbreaks quickly, BCT significantly lowers recall costs. Supply chain partners become trusted through BCT. This trust can be transferred from focal companies to financial institutions to investors, reducing transaction costs (Nayal et al., 2021; Zhang et al., 2022).
Source (S)	Waste management (S1): By reducing time delays and automating production tasks using smart contract applications, the BCT facilitates real-time order placement while maximising resource allocation. By optimising resource allocation, the BCT prevents food waste (Yontar, 2023).
	Regenerative facilitation (S2): By enhancing transportation management and tracking product life cycles, blockchain technology reduces carbon emissions (Yontar, 2023).

3.2 TOE framework for blockchain impediments

In light of the current situation of BCT in the FSC, TOE has been employed to address the current findings on the limitations of BCT status quo in the FSC (see Table 2). TOE provides comprehensive insights based on supply chain dynamics (Chittipaka et al., 2022). Technological refers to the technical impediments of BCT, which are inherent to the blockchain framework and must be addressed before comprehensive adoption in the FSC. Organisational perspectives explain the obstacles to implementation within FSC firms, as well as discuss the possibility of further BCT expansion. Additionally, environmental factors cannot be ignored. BCT applications must take into account both internal and external FSC compatibility, as well as other industry participants and the outer drawbacks from inadequate regulatory frameworks and slow rationalisation at the macro level of FSC (Friedman and Ormiston, 2022).

Table 2: Blockchain impediments in food supply chain

Main impediments	Sub impediments
Technological (T)	Privacy and reliability concerns (T1): BCT promises the transparency and immutability but might also compromise privacy and surveillance; BCT has not capability to verify the data authenticity uploaded by FSC actors (Friedman and Ormiston, 2022).
	Pragmatism (T2): Increasing demand of computing power, limited block sizes result in scalability issue. Besides, different food products require different blockchain solution which increase the difficulty for BCT adoption (Kumar et al., 2022; Vu et al., 2021).
	Inadequate expertise (T3): Incompetent FSC workers do not have the ability to fully comprehend BCT operation leading to lack of verification of data and affect the reliability of input data (Rogerson and Parry, 2020; Zhang et al., 2022).
Organisational (O)	Stakeholders intrust (O1): Customer – negative public perception associated with the ‘dark web’ of money laundering. Organisation – lack of collective commitment from top or middle management. Unwilling to share information due to concern about losing competitive power (Kouhizadeh et al., 2021).
	Stakeholder obligation (O2): Concern of what type of BCT is most suitable along with major shifting of organisational culture (Friedman and Ormiston, 2022).
	Resource constraint (O3): Limited resource (human, infrastructure, investment, etc.) to adopt BCT, and leaves inadequate for BCT integration (Kumar et al., 2022).
Environmental (E)	FSC internal compatibility (E1): The process of collaborating all actor on the blockchain is complex (Kayikci et al., 2020). FSC incumbents who benefited from untransparent FSC operation tend to reject the adoption of BCT (Friedman and Ormiston, 2022).
	FSC external compatibility (E2): Associated with governments, industries, and non-governmental organisations (NGOs). Lack of standard policies and framework and lack of engagement is slowing BCT adoption. Fear of accountability becoming predominant practice for which BCT practices will cost more for governments and institutions (Friedman and Ormiston, 2022; Kouhizadeh et al., 2021).

4. Conclusion

The study highlights the current state of FSC in light of possible blockchain adoption. Thematic analysis outlined potential performance enhancements which will be achieved by BCT-enabled FSC. During the study, the study demonstrated that BCT can facilitate effective resource management, provide transparency that is critical to FSC, increase integration among all FSC stakeholders, and improve performance. The implementation and expansion of BCT, however, may be impacted by technological, organisational and environmental barriers that remain to be addressed. Additionally, BCT can be integrated with other technology in order to facilitate human involvement in FSC practices, thereby reducing the chances of data misinput and diminishing unconditional trust in blockchain data. In conclusion, this study highlights several major obstacles to blockchain implementation in the FSC today, as well as feasible solutions in the future. Further research is required on this topic, including how to balance fragmentation of the FSC with the cost of using blockchain. Blockchain infrastructure is still expensive and requires improvement. An approach such as Blockchain as a Service (BaaS) could potentially decrease—

the cost of blockchain infrastructure. Combined with blockchain operations, artificial intelligence (AI) and other automation technologies could reduce the possibility of data manipulation and improve accuracy and efficiency in the FSC. As part of the development of blockchain, customers play an important role. Future studies may examine the reward and participation of customers for blockchain-enabled food products. By understanding blockchain technology, as well as purchasing blockchain-enabled products, food producers will feel more confident implementing blockchain technologies.

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CONTAINER PORT SELECTION CRITERIA: A CASE STUDY ON KOREAN SHIPPING COMPANIES

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1. Introduction

With globalisation and increase in world trade, competition among ports is fierce. Therefore, considering key port choice factors to determine which port is the most optimal for container vessels to call is crucial. Port selection process is complex and challenging as numerous influencing factors have to be considered.

According to Chen et al. (2018), from 1980 to 2010, China stood to be the world's most recent manufacturing hub. However, since 2011, the Chinese manufacturing began to decline as various capital and labour costs have increased over these 30 years and the cost advantage is waning. Relocation of global manufacturing in the modern history is a noteworthy topic since related logistics, shipping, and port companies will also move to the new manufacturing hub as they have done in the past throughout the past three major global manufacturing relocations (Chen et al., 2018). With cost advantage waning in China and the recent trade war between the U.S. and China, relocation of production facilities has been sparked and has been accelerating in the Southeast Asian countries (Bhaskaran, 2020).

Amidst such shift, South Korean multinational corporations' investment and interest in the Southeast Asian countries is considerable. Further, South Korea's scale of economy in the world and its high position within the maritime transport business make it worthwhile to further investigate key port selection factors that are considered for Korean shipping companies engaged in SSS to the emerging hotspots of the ASEAN region.

2. Literature

Choosing key port selection factors are different from region to region. For the European region, research indicate that congestion factor was of importance (O'Connor et al., 2020) as well as freight competitiveness and service capability (Lin and Wang, 2019). In the Asian region, it seemed that operations and cost were more of the focus. For the Northeast Asia, port's strategic location enabling connectivity and the cost factor were found to be important while service factor was found to be the least important (Park and Min, 2011; Yeo et al. 2014). In South Asia, port performance and operations factors were of more importance such as berth availability while liner's special preference and special contacts were of least importance (Veenstra and Notteboom, 2011; Kavirathna et al., 2018). Finally, as for Southeast Asia, cost aspect and hinterland economy were of the importance (Chou, 2010). According to the literatures, it seems that there are relatively few literatures on Southeast Asian region and especially fewer in number from Korean shipping companies' perspective.

There is a copious amount of port selection literature focusing on the Asian region or the non-Asian region and also from perspectives of various maritime-related stakeholder such as carrier or shipper / freight forwarder (Wiegmanns et al., 2008; Saeed and Aaby, 2013; Yeo et al., 2014; Sun and Zheng, 2016; Notteboom et al., 2017; Kavirathna et al., 2018; Park et al., 2019; Venkitasubramanian and Thill, 2019; Paolo et al., 2020). Above research have provided crucial analysis and insights for specific countries for both inside and outside of the ASEAN region. Although there are many research that have focused on the Asian region from carrier's perspective, research focusing on Southeast Asia from carrier's perspective for the case study of Korea have been relatively underexamined in the literature. Research into this topic could help to identify port selection factors from the perspectives of Korean carriers. There is indication that Korean trade with Southeast countries have been increasing - seen from the increase in shipping service routes and export container cargo volume into Southeast Asian region. Therefore, research into finding what the important port selection factors are from Korean carrier's perspectives is necessary.

3. Methodology

3.1 Systematic Literature Review

Systematic literature review method is used in this research as it is an evidence-based approach to best identify the most relevant secondary data to provide in-depth understanding about what is known (Colicchia & Strozzi, 2012). This study will be following the five steps of systematic literature review according to Denyer and Tranfield (2009). According to Denyer and Tranfield (2009), the SLR method is a tried and tested method that examines the bibliographic sources for a specific topic with the aim of delivering an organised outcome. Through its transparent and universally accepted structure, the SLR is not only replicable but also particular in that it categorises and analyses literature in a specific research area or topic. Additionally, the use of Denyer and Tranfield's (2009) SLR method have already been effectively used in numerous studies in the logistics and supply chain field (Abbasi, 2017; Rafi-UI-Shan et al., 2018; Tiwari, 2021). The five steps of SLR includes the following: (1) Question formulation; (2) Locating studies; (3) Study selection and evaluation; (4) Analysis and synthesis; (5) Report and using the results. Following the above-mentioned process, a total of 71 studies from two database were chosen as a final set of studies as shown in Figure 1 below.

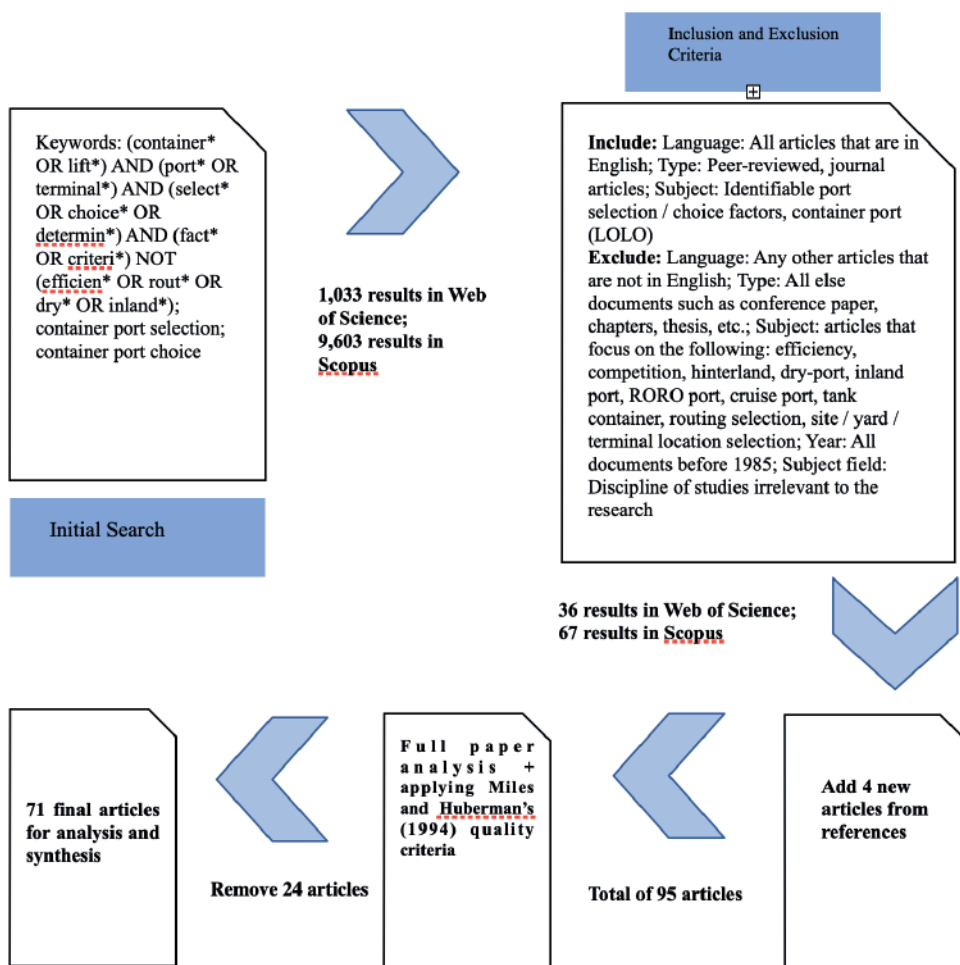


Figure 1: Article selection process

3.2 Semi-structured Interviews

A brief pilot test of the interview questions and the created hierarchy of port choice factors – obtained from SLR – was conducted with two academic experts in the shipping field. Afterwards, the hierarchy of factors underwent further adjustments using semi-structured interviews with senior experts in the industry. The advantages to using semi-structured interview are numerous. According to Yin (2003), when a research objective is to understand complex elements as well as their intersection of elements such as perceptions or values, semi-structured interview is appropriate. Semi-structured

interviews are used to discuss and refine port selection factors both in their order of importance and in their composition (main-factors and sub-factors) from the industry experts' input and point of view. Port selection factors in this stage are refined and hierarchised that help with accurate comparison of components involved in complicated decision-making process (Saaty, 1990).

3.3 Data collection and sampling

Primary data were collected using semi-structured interviews with three professionals from each of the top Korean shipping companies such as KMTC, Sinokor, and Namsung Shipping that operate SSS to ASEAN ports. Purposive sampling technique has been used to select the interviewees. The chosen interviewees have at least more than 10 years of experience in their respective companies. Additionally, the interviewed shipping companies make up for 52% of the sum share (both import and export) of the SSS from South Korea to South East Asia. As these three companies make up over half of the total sum share, their responses are seen as adequate in representing the responses to the various questions asked in the interview. For each expert, the interview lasted an average length of 45 minutes, and the interviews were conducted face-to-face in June of 2023.

4. Analysis

4.1 Analysis from SLR

The selected and evaluated 71 studies were analysed and synthesised according to particular themes. Four major dimensions were identified from the studies per port selection literature and these dimensions ultimately represent major factors that were used in port selection literature. There are numerous additional factors or sub-factors that are applied and discussed in port selection literature. However, these sub-factors fall within the major four factors that were identified from analysing the 71 studies. It is crucial that the number of factors be not too extreme in number. Further, each of the names of dimensions or major factors are carefully chosen to best represent the sub-factors that they cover and help the decision makers comprehend the situation better when undertaking interviews or questionnaires (Onut et al. 2011). The four major factors are defined below and sub-factors are also shown below.

1) Port location is a factor that is identified across the majority of port selection literature. Port location is outlined as the proximity to the following: import and export centres, corresponding feeder ports, and main navigation routes (Lirn et al, 2004). Another study outlines port location in regards to the following: main shipping lanes and immediate and extended hinterland (Wiegmanns et al, 2008). Zhao et al (2007) defines location as the following: "the natural condition of port and the distance from international line." Thus, the sub-factors include the following: proximity to feeder ports; proximity to main navigation routes; proximity to the markets (demand); distance of shippers from the port (supply).

2) Port charge is another important factor in port selection literature. Although port charges vary between ports in their structure and levels, according to Tongzon (2009), port charge is levied on the basis of port visits and/or cargoes. There are two types of port charge which are ship-based type (includes navigation fees, berthage, berth hire, harbor dues and tonnage) and cargo-based type (includes wharfage and demurrage). Here, Tongzon (2009) notes that berthage and berth hire are levied as net registered tonnes (NRT) and gross registered tonnes, respectively. Thus, the sub-factors include the following: port charges (port dues, pilot cost, towage, etc.); handling & storage cost of containers; Inland transport cost.

3) Port hinterland is another major factor identified that includes elements such as cargo volume, frequency of port of calls, and intermodal links. Port hinterland also encompasses various sub-factors across port selection literature. Hinterlands could be commodity-specific (Malchow & Kanafani, 2004) and intermodal connectivity is a determinant for market share of a port in certain hinterland regions (Valls et al., 2020). There are numerous studies that indicate the importance of port hinterland as the main factor of selecting a port. According to Chou (2007), the decision maker considers first the hinterland economy (cargo volume) and cost. Thus, the sub-factors include the following: total container cargo volume (import/export & transshipment containers); frequency of port of call; intermodal links.

4) Port efficiency is the last of the major factors identified and has sub-factors such as port infrastructure and port depth. There are studies that note the port efficiency factor as one of the major aspect of port choice decisions (Steven & Corsi, 2012; Cantillo et al., 2022). Port productivity, efficiency (Steven & Corsi, 2012) and port performance (Cantello et al., 2022) are indicated to be important factors when deciding on port choice. Additional factors listed throughout port selection literature such as port physical or infrastructure ultimately contribute to the port's efficiency. Thus, the sub-factors include the following: port infrastructure; container handling efficiency; container yard efficiency; customs efficiency.

In terms of studies dealing with port choice from the perspective of shipping companies, Steven and Corsi (2012) also categorises the literature into similar major factors as the following: port location; port charges; port efficiency, berth availability and size; and general infrastructure. Similarly, study from Nazemzadeh and Vanelander (2015) identified numerous sub-factors and classified them into main five factors which are the following: geographical location, port costs, hinterland connection, port productivity, and port capacity. Port productivity and port capacity mentioned in the above study indicate such attributes like available berths, cranes, storage, customs efficiency, and container yard efficiency which are attributes that are categorised as port efficiency in this current research. Table 1 shows a visual representation of the four identified main factors as well as their sub (detailed) factors obtained after SLR. It should be noted that the list of factors displayed in the third column is obtained through SLR.

Goal	Main factors	Sub (detailed) factors (1) after SLR	Sub (detailed) factors (2) after interviews
Container port selection factors	Port location	Proximity to feeder ports	Proximity to main navigation routes
		Proximity to main navigation routes	
		Proximity to the markets (demand)	Frequency of port of call
		Distance of shippers from port (supply)	
	Port charge	Port charges (port dues, pilot cost, towage, etc.)	Port charges (port dues, pilot cost, towage, etc.)
		Handling & storage cost of containers	Terminal Handling Charge (loading & unloading cost, etc.)
		Inland transport cost	
	Port hinterland	Total container cargo volume (import/export & transshipment containers)	Total container cargo volume (import/export & transshipment containers)
		Frequency of port of call	Proximity to the markets
		Intermodal links	Distance of shippers from port
			Intermodal links
	Port efficiency	Port infrastructure	Port depth
		Container handling efficiency	Number of gantry cranes / gantry crane handling capacity per hour
		Container yard efficiency	Area of container yard
		Customs efficiency	Port connectivity

Table 1: Display of port selection factors according to the literature

Notes: The main factors remained the same for both SLR and interviews. However, following the interviews, there have been rearrangement, rewording, and deletion of sub (detailed) factors initially obtained from SLR.

4.2 Analysis from semi-structured interviews

As part of the interview questions, the senior experts were asked for their input and comment on the hierarchy of port choice factors that was created after the author has conducted SLR. In general, the experts agreed on the presented hierarchy of structure, and the main factors remain the same for after semi-structured interviews. However, the interviewees provided inputs on the modification of specific terms, deletion of certain factors, and rearrangement of sub (detailed) factors into their more accurate main factors. The changed sub (detailed) factors after the interviews are listed in the last column of Table 1.

5. Conclusion

It is crucial to consider the key port choice factors in order to determine which port is the most optimal for container vessels to call. With the relocation of production facilities accelerating to Southeast Asian countries (Bhaskaran, 2020), it is noteworthy to undertake research in this region. South Korea has a high scale of economy and high position in maritime business. Additionally, its investment and interest in Southeast Asian countries are considerable. Further, taking into account that key port choice factors from Korean shipping companies' perspective involved in SSS in ASEAN region are underexamined, research into this topic could prove worthwhile. Through the use of SLR and semi-structured interviews, the researcher was able to obtain and create hierarchy of port choice factors from Korean shipping companies involved in SSS with Southeast Asian countries.

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A SYSTEMATIC REVIEW OF POLICIES AND REGULATIONS IMPACTING SUPPLY CHAINS

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Introduction

Recent supply chain disruptions (e.g., Covid-19, Ukraine war, climate change) have triggered a new wave of policy interventions with policymakers accelerating their responses in a variety of ways from import/export bans to fiscal regulations and due diligence acts (Botwright and Verghese, 2022). In the EU for example, new rules will require companies to disclose information on their environmental and social impact, and failure to comply could result in fines or legal action. In Germany, the newly introduced Supply Chain Due Diligence Act requires companies to check supply chains especially for potential violations of human rights (Rowse, 2023). Similar regulations are also taking place in other countries of different continents such as Canada (Phillips, 2022). Following these regulations, some major car manufacturers such as Mercedes-Benz, BMW, and Volkswagen are being accused of failing to take appropriate measures (Schappert, 2023).

Changes in regulations and government policies can have a dramatic and large-scale impact on supply chains, however, research in this field is scant and our understanding of the actual consequences of the policies and regulations (P&R) is limited. Current research focuses on policy instruments and processes of specific countries or regions, but the modern nature of global cross-border chains requires a more integrated approach and more evidence on the associated implications of the various country specific P&Rs (Jiang et al., 2021; Tuominen et al., 2022).

This paper attempts to address this gap by conducting a systematic literature review (SLR) of recent peer reviewed articles and grey literature (e.g., policy documents). The aim of this research is to provide a comprehensive review of the regulations and policies introduced worldwide and analyse the key implications for supply chains. This research seeks to address the following questions:

RQ1. What P&Rs globally are in place to cope with supply chain disruptions?

RQ2. How can these P&Rs help to alleviate the pressures on modern supply chains?

Methodology

We have adopted SLR to have a comprehensive view of the global P&R landscape and its direction over the last ten years. Compared to a traditional literature review, SLR is more robust and transparent and summarises existing information in a thorough and unbiased manner (Tranfield et al., 2003).

The research protocol followed in this review was adapted from Tranfield et al., (2003) and started with a scoping study that informed the research question. Keyword groups (i.e., strings) were formed (S1 for policy-related keywords, S2 for supply chain context, and S3 for disruption-related keywords). Keyword strings were gathered and combined with the 'AND' operator (Figure 1) to search Scopus for articles and Google for grey literature in separate instances.

A list of criteria was considered during the scientific study selection process. Only articles and reports from 2013 were considered relevant owing to the recency of P&Rs. From 2013, 38 sources in English on P&Rs introduced by major countries and trading blocs were included. Authors also expected to see insights about the implications of mentioned P&Rs on supply chains in the sources. In addition to the 38 selected sources, three reports and five news articles were included from the grey literature as a result of reference snowballing which increased the total number of sources to 46.

This study is an attempt to categorise P&Rs with respect to their targeted megatrend themes. Kalaitzi et al. (2021) offers a framework followed by a PESTLE analysis. This paper adopts that strategy and following the selection process, through a thematic analysis, the megatrends of these P&Rs were identified for categorisation purposes. Finally, the implications of these P&Rs were discussed under separate supply chain sub-sections.

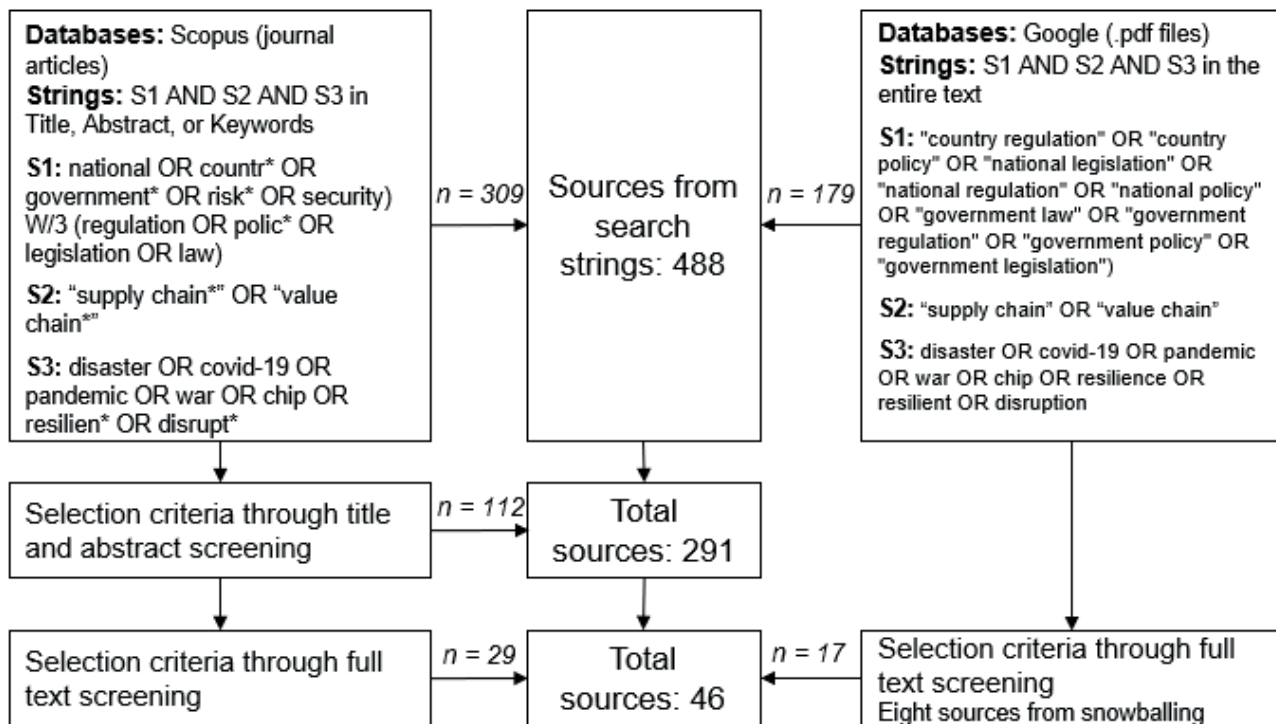


Figure 1: The systematic literature review process

Overview of megatrends and relevant P&Rs

As stated in the methodology chapter, this paper adopts the categorisation strategy of Kalaitzi et al. (2021) to identify the megatrends of each P&R (Table 1).

Name of P&Rs	Name of country / trading blocs	Aims / details	Megatrend theme
Corporate due diligence in supply chains	EU, Canada	To improve protection of human rights among the global supply chains (e.g., preventing child and forced labour and banning substances harmful to environment)	Environmental, social, governance
Automotive policy	Canada, USA, Mexico (CUSMA)	Tariff-free treatment to ensure most parts of the passenger vehicles and lights trucks are produced in the region	Electrification of transport
Manufacturer subsidy program	Honk Kong, Japan, Germany, Italy	Temporary manufacturer subsidy to increase mask availability	Catastrophic events
Price control policy	Italy, China	Temporary face mask price control to increase mask accessibility	Catastrophic events
Food security policy	China, Argentina, Italy	Temporary subsidies to agriculture (e.g., farmers, fisheries, processing companies) to restore food production and regulate food prices	Catastrophic events
Cybersecurity policies	China	Strengthen technological ecosystem to protect the nation, society, and supply chains	Cybersecurity
Rare earth stockpiling policy	China	Government built storage for rare earth elements and oxides	Resource scarcity
Rare earth export quota	China	Government restricted the export of rare earth elements	Resource scarcity

Rare earth export tax	China	Government increased taxes on valuable rare earth elements	Resource scarcity
Pig farm P&Rs	China	Temporary loan discounts and price control to ensure pork supply	Catastrophic events
Food safety policy	EU	To ensure a transparent risk assessment is being conducted in the entire supply chains rather than only 'from farm to fork'	Resource scarcity
Freight transport policy	Colombia	'Safe points' for drivers for disinfection and temporary suspension of toll collection for freight vehicles in national roads	Catastrophic events
Biofuels blending mandates	Global (especially EU)	To trigger a movement from fossil fuel to biofuel to reduce carbon emissions of transportation	Environmental, social, governance
Monetary covid relief policies	Eastern Europe and Asia (ECA)	Temporary wage subsidies, cash transfer, fiscal exemptions, and credit policies for companies	Catastrophic events
Agricultural promotion policy	Nigeria	Creating self-sufficiency especially for rice and wheat while developing vibrant export markets simultaneously	Protectionism and global trade shift
Framework for climate and energy policies	EU	To enhance low carbon energy systems to combat climate change	Environmental, social, governance
Biomass policy	UK	Funding with the ambition for the UK to become a sector leader in biomass production, and develop carbon offset market and UK timber for construction	Environmental, social, governance
Defense production act	USA	To temporarily taking the authority over the private sector in times of crisis to accelerate the development, manufacturing, and free-of-charge distribution of relevant products	Catastrophic events
Export license requirements	China	Certification to ensure that exported items meet quality and safety standards for reputational purposes	Consumer protection laws
The Pacific trade alliance	Chile, Colombia, Mexico, Peru (Pacific Alliance)	Addressing frictions and harmonising technical standards in sectors such as cosmetics, pharmaceuticals, and food to reduce the time and cost of trade	Supranationalism
Economic security promotion act	Japan, Korea	Subsidies for firms to relocate their production out of China and install new infrastructure to meet cybersecurity criteria	Protectionism and Cybersecurity
Emergency response	China	Temporary epidemiological investigations, social distancing, and quarantine mandates to stabilise and sustain manufacturing operations	Catastrophic events
Emission control areas policy	EU and USA	To control emissions from international shipping and limiting allowed sulphur content for ships in controlled areas of ports	Environmental, social, governance
Risk preparedness regulation	EU	Aims to establish EU energy markets and secure energy supplies	Environmental, social, governance
Agricultural policy	EU	To ensure fair income to farmers, preserve biodiversity, protect food and health quality, and act against climate change	Environmental, social, governance

Welfare and poverty alleviation programme	India, China, Nepal, Pakistan, Uzbekistan	Temporarily prioritise food availability and affordability through production and distribution incentives	Catastrophic events
U-turn law	South Korea	Subsidies and tax reductions for reshoring South Korean manufacturing companies involving better incentives for regional development (reshoring out of Seoul)	Protectionism
Tourism policies	Taiwan	To minimise the spread of Covid-19 and gain trusts of tourist to sustain tourism and hospitality industry	Catastrophic events
Forest investment program	Nepal	To reduce foreign imports and mitigate the impacts of climate change, incentivising forest land rehabilitation, improving private forestry, and creating rural jobs	Environmental, social, governance and global trade shift
Disaster risk management	Nepal	Adopting processes in infrastructure and construction to achieve sustainable development goals and create a disaster resilient Nepal (similar to Build Back Better Act of the USA)	Environmental, social, governance
Fashion sustainability and social accountability act	USA	Environmental and social disclosures (risks, actions to mitigate them, and measures to track results) for fashion retailers and manufacturers in supply chain	Environmental, social, governance
Free trade agreement	USA - Korea	Battery cells and packs for electric vehicles that meet the predefined regulations enter the USA tariff-free	Supranationalism
Modern slavery act	UK, Australia	To make the companies report on modern slavery risks in their operations and actions taken against them to protect human rights	Environmental, social, governance
Conflict minerals regulation	EU	Importers of elements such as tin, tungsten, tantalum, and gold should comply with social guidance of OECD	Environmental, social, governance
Plastic packaging tax legislations	UK	Extra tax for packages produced in or imported into the UK that contain less than 30% recycled plastic	Environmental, social, governance
CHIPS act	USA	Funding for semiconductor companies to manufacture chips domestically and reduce reliance on foreign-made semiconductors	Electrification of transport
Digital new deal and Green new deal	Korea	Increase employment and social safety net through building renovations, incentivising electric car production, and ensuring local development including digital and green initiatives	Electrification of transport
Inflation reduction act	USA	Incentives that aim to create new sustainable industries with cleantech such as green hydrogen	Environmental, social, governance
Bipartisan infrastructure law	USA	Incentives to replace value chains based on internal-combustion engines with electric and battery alternatives	Electrification of transport
G7 Clean energy economy action plan	EU	To enhance global resilience through supporting low and middle- income countries and incentivising a narrow set of sensitive technologies that could threaten peace	Technology development
Carbon border adjustment mechanism	EU	Aims to equalise the price of carbon in domestic products and imports so that EU climate objectives are not undermined through less ambitious non-EU countries	Environmental, social, governance

Alliance on processors and semiconductor technologies	EU	Focuses on identifying the gaps in production of microchips and expanding domestic production. Also includes stockpiling of significant products	Electrification of transport
Modern manufacturing initiative	Australia	Scaling up national businesses and integrate them into international supply chains (topics include space, medical applications, critical minerals, recycling, clean energy)	Global trade shift
Supply chain resilience initiative	Japan, Australia, India	Aims to jointly enhance use of digital technology in supply chains, share best practices, and support trade functions between the countries	Digital transformation
Semiconductor R&D fund	Taiwan	Fund to attract foreign companies to develop semiconductor R&D projects in Taiwan	Global trade shift
National environmental policy act	USA	To promote domestic lithium projects while ensuring a minimised negative environmental and health impact	Environmental, social, governance
Dual circulation	China	Make national manufacturing self-sufficient through less reliance on foreign technology	Protectionism

Table 1: Overview of P&Rs and their megatrends

Overview of the implications of P&Rs on supply chains

This chapter discusses the major implications of P&Rs in Table 1 on supply chains through three interrelated sub-sections to emphasise all these significant concepts separately.

Supply Chain Design

Following the pandemic and similar catastrophic events, protectionism has become a prevailing megatrend with companies now considering reshoring and friend-shoring in their supply chain design. Therefore, in response to covid; the United States, Japan, Korea, and many other countries are actively trying to reduce their dependence on certain countries (e.g., China) (Katada et al., 2023). World Trade Organisation (WTO) rules leave states with policy space to adopt certain kinds of P&Rs. Mostly adopted examples are subsidies for firms that diversify their supply chains geographically or adopt other kinds of regulations to bolster resilience (Meyer, 2020). Given that these types of subsidy flexibility are only provided during a crisis, reshoring production is not the lesson to draw from the catastrophic events, as that would be a costly exercise without the guarantee of improving supply availability with further shock hits.

Reshoring or renationalization comes with its own challenges and research by Kersan-Škabi (2022) has shown that there are implications for drop in welfare, GDP, and an increased supply chain vulnerability. A better solution would be to enhance the ability to source supplies rapidly and for firms, no matter where they are located, to respond in ease (e.g., The Pacific Trade Alliance). Catastrophic events have highlighted the importance of collaborative, extensive relationships with suppliers for supply chain resilience. (Botwright and Verghese, 2022). To spot the potential bottlenecks that impede the flow of supply, companies should develop systems to monitor market conditions (Findlay and Hoekman, 2021). For these bottlenecks, they need to proactively diversify the production and transportation when necessary and enlarge the supply chain to rapidly respond to changes in demand (Findlay and Hoekman, 2021; Kersan-Škabi, 2022). Companies can also prefer replacing long-distance imports/exports with those that are closest and regionalise the operations as much as they can (Kersan-Škabi, 2022). Therefore, diversification, collaboration, resilience, and regionalisation are processes which will be focused even more in the future.

Another potential impact of pandemic on supply chain designs are temporary takeovers as observed in the United States. 'Defense Production Act' which gives the president authority to require companies to accept "priority-rated" contracts, which were used for Covid-19 vaccines and creating a new supply chain from scratch. Thanks to the flexibility in their supply chain design, the United States became the first economy outside of China to make 100 million doses of vaccines publicly available (Bown, 2022).

Supply Chain Resource Scarcity and Security

Disruptions in trade flows and agreements also have a significant effect on security of supplies such as rare earth elements (REE) which are considered as strategic resources for supply chains. Imposing export or production quotas is justified as a response to market imperfections or on the grounds of protecting the environment and resources. Export controls can be counterproductive, as they can cause shortages of key inputs supplied by foreign companies, if they lead to tit-for-tat retaliation or emulation (Kersan-Škabi, 2022). Furthermore, quotas can impact prices negatively and put the entire global supply chain into risk. In such cases, there can be policies to ensure supply to domestic downstream industries. Particularly, WTO and international rules help to strengthen the supply, reduce prices, and strengthen the resilience (Mancheri et al., 2019). Alternatively, to ease the concerns about national needs and ensure adequate supplies of strategic resources, stockpiling became an essential P&R response in supply chains (Marcin, 2021; Meyer, 2020).

Another supply chain response to resource scarcity and ongoing environmental concerns is leaning towards renewable energies for sustainable supply chains. There are many incentives for the supply chains that encourage companies to use renewable energy and decrease overall carbon footprint (Azadeh and Vafa Arani, 2016; Gollakota and Shu, 2023). For example, Europe and India are developing policy initiatives (mainly mandates and incentives) and programs to counter China's leading position in lithium-ion battery production and to localise supply chains within their own regions. Further, governments and companies are investing in new battery chemistries to reduce costs, limit the use of sensitive raw material inputs, increase energy densities, and meet other needs ("Building Resilient Supply Chains", 2021).

Cybersecurity is another aspect to address for secure supply chains. There is supply, operational, and customer risks that can be attributed to cyberattacks. Some of these risks are theft of vendor credentials, breach from the vendor network, malwares and malfunctioning of the plant, intellectual property theft, and manipulation of data (Pérez-Morón, 2022). Supply chains should expedite the implementation of cybersecurity measures (e.g., Japan's Economic Security Promotion Act) to prevent potential disruptions ("Japan's Economic Security Promotion Act", 2022).

Supply Chain Social Sustainability

Social sustainability and human rights play a significant role in P&Rs. Main examples are supply chain and corporate due diligence acts, especially taking effect in the EU, that urges companies on regular evaluation of procedures, actions to prevent or mitigate relevant supply chain risks, and developing a system for monitoring measures implemented (Botwright and Verghese, 2022). Companies are expected to be in line with the Paris Agreement (limiting global warming) and publicly transparent in reporting including non-EU partners to comply with the EU due diligence act (Holger, 2023). Therefore, thousands of non-EU companies (e.g., American, British) will have to step up their sustainability reporting under EU rules, to increase visibility and transparency on everything from their greenhouse gas emissions to gender pay differences (Holger, 2023; Rowsell, 2023). Failing to comply could result in fines of up to 2% of their global turnover. Furthermore, it may cost the entire business relationship for the non-compliant companies (Rowsell, 2023). Thus, to achieve the desired outcome of contributing to social sustainability goals while maintaining efficient operations, the supply chains should be designed in a way which enables the internalisation of potential negative external issues without creating non-tariff trade barriers (Kolev and Neligan, 2022).

Finally, and obviously, catastrophic events also negatively influence social sustainability. Even in the presence of Covid-19 relief policies, a sharp reduction in physical and remote workers is observed in inefficiently designed supply chains (Wu, 2023). Therefore, the focus should be on the efficient design of supply chains (e.g., through digitalisation and automation if suitable) to be able to deal with these types of threats and disruptions without the negative social consequences.

Conclusions

At this moment, economies and societies are enduring several crises at the same time and this era of disruptions has negative and long-term humanitarian consequences. Climate change, the pandemic, wars, natural disasters, inflation, and trade disputes pose urgent questions that should simultaneously be addressed by supply chains. However, there is currently a lack of studies examining P&Rs imposed globally in the extant literature. To our knowledge, studies focus either on a country/region (Bown, 2022; Olomu et al., 2020; Wu et al., 2020) or on a certain type of supply chain such as maritime (Zavitsas et al., 2018) or manufacturing (Chen et al., 2023). This paper represents one of the first attempts to fill in this gap. This study is a first step towards understanding the effects of P&R on supply chains, and it encourages further research

to enrich our findings. Also, the emerging Table 1 links P&Rs to megatrends for a better understanding of P&Rs and their implications. As the modern supply chains are becoming more and more integrated, managers can prepare their companies to these implications even if such measures are not in place in their domestic supply chains.

There is a still underdeveloped potential of public–private collaboration to ensure resilience in supply chains. P&Rs play a significant role to manage and enhance the ongoing collaborations to develop robust supply chains. Therefore, a continuous wave of policy updates addressing the megatrends is key to resilient and sustainable supply chains. However, policymakers also should be attentive about how controlling they are on companies even in times of crisis (Rowse, 2022), to be able to efficiently dictate the supply chains. This paper can be helpful to policymakers by providing P&Rs throughout the world and the implications they bring to supply chains.

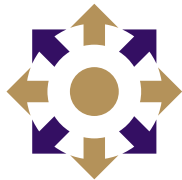
As with any study, there are limitations to this paper. Firstly, the research reviewed is based on two specific databases (Scopus and Google). Thus, its outcomes cannot completely reflect all P&Rs imposed by different nations and trading blocs against supply chain disruptions.

Future research can focus more specifically on trading blocs (e.g., EU, CUSMA) for deeper insights about the supply chains of those blocs. Likewise, a specific industry can be addressed to capture all the relevant P&Rs and their implications on the selected industry. Further, the areas where future policies will need to be developed to support resilience and effectiveness of supply chains can be identified. Finally, projections of potential P&Rs can be evaluated through scenario building and analysis including extreme and unforeseen scenarios. Even though it is often difficult to quantify the impact of P&Rs on supply chains, a quantitative analysis would be insightful both to managers and policymakers in the ecosystem.

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