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(ISL 2024)

Building Sustainable Connectivity through Logistics and Supply Chains

07-10th July 2024

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INTRODUCTION

We are delighted to welcome our friends and colleagues, both old and new to the 28th International Symposium on Logistics. This year's event provides a distinctive opportunity for the ISL community to debate some of the global geopolitical challenges facing the world and their knock-on effect on the management of supply chains. The underlying reasons for the increased geopolitical turbulence and uncertainties is primarily due to the current ongoing conflicts between Russia-Ukraine, Israel-Palestine, the trade war between China and the USA, and the environmental uncertainties which have been debated extensively during previous ISL events. All these insecurities have impacted supply chains in different ways. These include higher energy and fuel costs, which in turn has resulted in increased manufacturing, logistics and supply chain costs. Other issues such as delays in shipments due to re-routing, disruptions in sourcing, reduced flexibility, skill shortages and increased complexity, etc. is a major concern for many logistics and supply chain planners and managers.

The organising committee, based on learning from previous hybrid ISL conferences, decided to continue with the hybrid mode again this year, which worked quite well during the ISL 2022 and 2023. This year's conference although primarily face-to-face, also offers all online participants access to the online presentation sessions, as well as the keynote presentations. Whilst the hybrid mode is not an ideal context to network, it is an acceptable compromise considering the concerns around sustainability issues, as well as increased levels of travel restrictions imposed by many universities around the globe.

Bearing this in mind, two categories of paper submissions were invited. The first category was so called 'Full Papers' - that is up to 8 pages in length along with a one-page structured abstract. These types of papers were subject to a peer review process. These papers, if accepted, are included in part 2 of the Proceedings of the Conference with an ISBN number. The second category were structured abstracts of 1000 words. These may be considered as developmental papers, representing early-stage research ideas or initial findings. Only the abstract was required for the initial submission, which underwent the review process. Both types of paper submissions – full papers and structured abstracts – were considered for an invitation to submit to the special issue of the International Journal of Logistics Management or Computers and Industrial Engineering. The duration of the in-person presentations was 30 minutes (including Q&A), whilst the online presentations were for 15 minutes during the two-day event.

Considering the increased trend towards digitalisation of supply chains operations and the greater need and challenges to address physical and digital connectivity, this year's theme was chosen as *'Building Sustainable Connectivity through Logistics and Supply Chains'.* This 28th ISL aims to provide a forum for both academics and practitioners to discuss the current and future research in the area of logistics and supply chain management. The papers in this book of proceedings represent the latest in academic thinking, as well as case examples of successful implementations. The 28th ISL also presents an opportunity to engage in various discussions and debates during the course of the event, exploring how our models, concepts and findings are pushing the frontiers of knowledge in the area of logistics and supply chain. Equally, it is important to explore how our cumulative know-how in our discipline can be successfully applied to develop the next generation of experts through our teaching and curriculum development as well as helping the practitioner community to enhance the competitiveness of industry.

For us as event organisers, we have been able transfer learnings associated with using online platforms from last year and combine it with expertise generated over the years in hosting physical events to deliver an excellent experience for our ISL delegates. We are delighted with the success in terms of number of submissions, resulting in 82 paper presentations representing authors from 36 countries. In addition to this, we were fortunate to have two excellent keynote speakers namely Professor Ruth Banomyong, Thammasat University, Thailand and Bunn Kasemsup, CO-CEO, SCGJWD Logistics Thailand. We were also pleased to host a workshop on '*Designing cascades for systemic circularity in material/product circular supply chains*' ably led by Prof. Rudrajeet Pal, University of Borås, Department of Business Administration and Textile Management, Boras, Sweden and Prof. Erik Sandberg, Linköping University, Industrial Engineering and Management, Linköping, Sweden.

Overall, the event proved to be highly successful considering the variety of activities ranging from keynotes, paper presentations, workshops, debates, etc. These were further supported by online virtual group discussions and debates between delegates. All these activities enabled the ISL community to maintain its tradition as an informal, yet productive and knowledge-intensive event – all in all culminating in another memorable experience and successful event.

As mentioned above, and as in previous years, all abstracts and/or full papers were reviewed by two or more academic experts from the field of Logistics and Supply Chain Management. This book of proceedings containing the accepted papers, has been organised in 2 parts according to the following categories:

Part I: Abstracts

- Smart/digital connectivity in logistics and supply chains
- Supply Chain Analytics
- Sustainability in Logistics and Supply Chains
- Building resilience for supply chains
- Globalisation of Supply Chains
- Logistics Connectivity
- Humanitarian Logistics
- Building resilience for supply chains
- Supply Chain Skills, Training and Education

Part II: Full Papers

- Smart/digital connectivity in logistics and supply chains
- Supply Chain Analytics
- Sustainability in Logistics and Supply Chains
- Building resilience for supply chains
- Globalisation of Supply Chains
- Logistics Connectivity

To date the ISL has been held in Europe, South Africa, Australia and Asia (see full list below), and the last couple of events were in hybrid mode. Last but not least, we would like to take this opportunity to express our sincere thanks to all the presenters, delegates, reviewers, Advisory Committee members, organising team, invited guest speakers, partner journals - International Journal of Logistics Management (IJLM) and Computers and Industrial Engineering (CAIE) for their valuable support and contributions. Finally, our special thanks go to Professor Ruth Banomyong, Thammasat University, Thailand for hosting the event and to his excellent colleagues at the university for the organisational support for the entire event. We are equally indebted for organising the very popular industrial visit to Toyota, Thailand.

Professor Andrew Potter, Professor Kulwant S Pawar, Professor Helen Rogers, and Professor Ruth Banomyong – July 2024.

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Building Resilience for Supply Chains

Globalisation of Supply Chains

Logistics Connectivity

WORKING PAPERS (ABSTRACTS)

Smart/digital connectivity in logistics and supply chains

Achieving food supply chain sustainability through digital sharing platforms: prospects in China

Shuang Tian[1], Lin Wu[1], Kulwant S. Pawar[1], Ming Lim[2]

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Purpose of this paper:

Our current food system falls short in sustainability, with a stark imbalance evident downstream in the food supply chain (Ribeiro et al., 2018). Official data underscores this issue, revealing that approximately 30% of the world's food supply, equivalent to 130 million tons annually, is squandered—a quantity capable of addressing the food insecurity of three billion individuals. However, effectively mitigating food waste proves to be a formidable challenge. Extant scholarship duly recognizes the complexities inherent in rendering the food supply chain more sustainable (Ciulli et al., 2020). The lack of connectivity among various stakeholder emerges as a primary obstacle, hindering the seamless flow and recycling of food along the chain.

Industry 4.0 has responded with technology-driven innovations, including digital food sharing platforms aimed at efficiently redistributing surplus food. These platforms represent a pioneering business practice within the digital food sector, providing individuals with the means to share surplus food and combat edible food waste (Harvey et al., 2020). They are perceived as instrumental in addressing sustainability challenges by establishing a marketplace for surplus food exchange, donation, and trade (Schanes and Stagl, 2019). Supply chain connectivity emerges as crucial for enhancing the value proposition of these platforms, facilitating seamless integration and collaboration among stakeholders to ensure efficient food redistribution and waste reduction. Despite its significance, research on factors influencing individuals' attitudes towards connecting through these platforms remains limited. Our study aims to explore these factors and understand individuals' intentions to adopt food sharing platforms, given the reluctance observed among potential users.

Design/Methodology/Approach:

This study adopts a qualitative approach to explore users' inclination towards adopting digital food sharing platforms, recognizing the novel dynamics of food redistribution through digital technologies and the inherent complexities involved. Selecting China as our study setting capitalizes on its burgeoning sharing and platform economy, which notably lacks digital food sharing platforms like Olio, thereby presenting distinct challenges and opportunities. Additionally, the Covid-19 pandemic has amplified people's receptiveness to digital innovations, particularly in the realm of food access, rendering China a fitting context for our investigation.

Data collection employed a vignette-based approach to simulate a food-sharing app akin to Olio (Verneuer-Emre et al., 2022). Participant recruitment was facilitated through WeChat, utilizing snowball sampling to tap into social networks effectively. Interviews, conducted in Chinese on the WeChat platform, with explicit consent obtained from all participants. The determination of a sample size of 35 participants was guided by the principle of information saturation. Thematic analysis, rooted in grounded theory, guided the examination of collected data (Gioia et al., 2012).

Findings:

The study confirms the significance of factors derived from existing technology acceptance theories, encompassing performance expectancy, effort expectancy, social influence, hedonic motivation, facilitating conditions, and price value, in shaping individuals' intention to embrace food sharing platforms. However, the distinctive attributes of this technology, particularly its emphasis on food exchange and strong sustainability dimension, alongside

cultural variations in perception, reveal additional critical factors influencing potential users' adoption decisions.

Content-specific factors emerge prominently, notably the pivotal role of trust in fostering participation in sharing activities within the food sharing platform ecosystem. Trust manifests as a two-dimensional construct, encompassing trust in other users and trust in the platform itself. Concerns regarding trust in other users revolve around food safety, quality assurance, personal safety, and potentially fraudulent activities. Equally significant is users' trust in the platform, which hinges on perceptions of institutional reliability and structural assurances inherent in online environments.

Moreover, context-specific factors, such as "losing face" (Mianzi) and other negative emotions, alongside apprehensions regarding infection transmission, are identified as influential contextual determinants guiding individuals' decisions regarding the adoption of food sharing technology. These findings underscore the intricate interplay between individual beliefs, socio-cultural norms, and environmental concerns in shaping the acceptance of digital food sharing platforms.

Originality/value:

Our study validates established technology acceptance models and uncovers novel insights into factors specific to digital food sharing platforms, offering critical considerations for adoption. In addition to confirming the significance of factors like performance expectancy, effort expectancy, and social influence, we highlight the impact of content-specific elements. The quality, variety, and presentation of food items, alongside trust considerations, emerge as crucial determinants of platform acceptance. Moreover, our study illuminates the influence of cultural and social contexts on online food sharing behavior, such as the concept of "losing face."

Of particular significance is the role of supply chain connectivity in facilitating the seamless operation of these platforms. Our findings underscore the importance of seamless connectivity, efficient communication and collaboration among stakeholders within the food supply chain to ensure the timely and effective redistribution of surplus food items. By highlighting the critical role of supply chain connectivity, our research contributes to enhancing the efficiency and sustainability of digital food sharing platforms. These insights inform communication strategies and regulatory frameworks, fostering an environment conducive to platform adoption and sustainability. Practically, our research aids platform practitioners and policymakers in navigating the Chinese market, enhancing food redistribution efforts, and addressing user concerns. By fostering collaboration, we promote the success of sustainability-focused innovations in the food sector.

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Empowering supply chain innovation to enhance GI food sustainability in China: A case study of JD.com and its collaborative food producer

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1: Newcastle University, United Kingdom; 2: Michigan State University, US

Purpose of this paper:

Geographical indications (GI) protect the names of products from particular regions, possessing distinctive characteristics, qualities, or a renowned reputation, shielding them from imitation or deceit under rigorous standards in the region of origin. By 2009 the GI systems were used in 167 countries and regions. European Commission has been prompting GIs system since 1992, advocating three schemes on the legal framework to promote and protect names of agricultural products and foodstuffs, namely protected designation or origin (PDO), protected geographical indication (PGI) and traditional speciality guaranteed (TSG). Based on the evaluation of empirical research, it shows that GIs may leverage economic benefits in the value chain, including sustaining price margin and increasing income for small food producers, stabilising the market demand, yet the research is remained infancy and lack of systematic view (AND International, ECORYS and COGEA, 2020). Understanding the relationship between the diffusion of GIs and innovation in the food system show substantial theoretical gap in the current literature (Stranieri et al., 2023). In this regard, the purpose of this study is to investigate how supply chain innovation can influence GI food practices, addressing on the economic, environmental and social impacts of sustainable development.

Design/methodology/approach:

Due to the fact that China has become the country with largest number of registered GIs and collaborated with the EU system in bilateral trade agreements in recent years (European Commission, 2021), the study was development in China. JD.com is one of the biggest e-tailers in China, endeavouring to establish logistics infrastructure and empower supply chain innovation to support small food producers in rural areas. The JD.com make prior to integrate supply chain structure and comprehensive intelligent platforms to build the bridge between supply chain demand (Shen and Sun, 2021), contributing significantly to food growers, particularly those situated in rural regions characterized by underdeveloped logistical infrastructure. This study uses JD.com and its collaborative GI food – King Crab as a case study in research design, adopting institutional theory and agency theory to investigate the interactions among JD.com, local government, co-operative, and food producers (King Crab) at multi-level perspectives. Data collection in this study encloses interviews with main coordinators in JD.com, government representative, co-operative manager, and local food producers. Secondary data, including company reports, online sources, and online sales data were captured in a nutshell, providing an overarching view of the case. All data were coded and analysed in NVivo 14. Thematic analysis method was used to interpret and analyse the contexts.

Findings:

This study visualises the farm to fork business model established by JD.com. In technological innovation, by using blockchain technology across all activities in supply chains, from farming, first mile logistics, warehousing, distribution, last-mile delivery and retailing, JD.com has successfully achieved traceability in full chains, delivered to consumers from over 300 cities in China. The case also shows far-reaching process innovation in short food supply chain. JD.com's business model involves direct procurement of fresh food, such as King Crab, from local food producers. The company undertakes tasks of sorting, packing, and storing in front warehouses situated near the producers. Additionally, JD.com takes responsibility for delivering orders directly to end consumers, accomplishing this within 24 hours in major first-tier cities in China.

The innovative changes in process innovation have yielded supply chain structure innovation in terms of restructuring and reconfiguring conventional supply chain. JD.com acts as in a principal role to provide manufacturing standards, materials, and technologies for local producers. The local food co-operative acts as the agent to closely work with local food producers, compliance with the standards from JD.com, local and government regulations.

The case shows substantial sustainability impact. For economic benefits, it has increase farm level incomes, supply chain efficiency and rural regional development. Besides, the collaboration between JD.com and the King Crab has enhanced marketing performance by creating brand awareness for the King Crab by promoting it in the digital platform. By saying that, it has substantially extended the market scale for the GI food. Environmental sustainability lays upon the monitor of biodiversity and eco-environment during farming. In addition, by integrating all logistics activities in JD.com from farm to fork, it potentially reduces the environmental footprint by optimising the logistics capacities via central computerisation. This case significantly enhances social sustainability by generating employment opportunities for elderly individuals and minority groups in rural areas through crab farming initiatives within inclusive communities. Additionally, it has boosted female employability by enabling them to sell and promote GI food products online through digital platforms.

Value:

This instance exemplifies a collaborative effort involving digital platforms, rural food producers, and corresponding stakeholders to advocate for the sustainability of GI foods. The novelty of this study lay upon the contribution of taking a multi-level perspective to visualise how technology innovation, such as blockchain works from farm to fork, and the linkage among process innovation and supply chain innovation. Complexity of agency role and institutional forces have been considered in the discussion of making systemic changes for GI food sustainability practices in China and other emerging economies.

Keywords: Geographic indication food, supply chain innovation, sustainability

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Risk management of transaction security using blockchain technology in the international logistics industry

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Purpose of this paper:

Most global logistics industries will introduce blockchain technology to provide safer payment channels for new transaction types and trade models. This payment channel does not require any trust mechanism for transactions. Therefore, they will pay attention to the risks of transaction security and introduce blockchain transaction systems to improve the industry's profits. A literature review and questionnaires outline the four dimensions and 20 quantitative factors of the risk management of the international logistics industry's blockchain technology transaction security application.

Design/methodology/approach:

This research mainly uses the Analytic Hierarchy Process (AHP) to explore the risk management of the international logistics industry's application of blockchain technology transaction security and, through the Risk Matrix, to summarize and take countermeasures.

Findings:

The results of the literature review and questionnaire survey are summarized as follows:

1. Explore the international logistics industry's understanding of transaction security. The international logistics industry understands transaction security because it must pay great attention to customer data and transaction security. Therefore, in terms of evaluation aspects, the study results show that "financial risk" is the most critical assessment aspect affecting the transaction security of international logistics operators using blockchain technology, followed in order by "environmental risk," "management risk," and "supply chain risk."

2. Discuss the risks that may arise from transactions using blockchain technology. Regarding the criteria for each assessment aspect, the research results show that "information trust" is the most critical assessment criterion in the environmental risk aspect; "cost reduction" is The most critical evaluation criterion in the financial risk aspect; "Operational risk" is the most critical evaluation criterion in the supply chain risk aspect; "Data security" is the most critical evaluation criterion in the management risk aspect; and finally "cost reduction" is The most critical evaluation criterion in the overall operating environment aspect is that transactions on the blockchain are cleared, settled and audited during the confirmation process. This can save workforce and material resources compared to the traditional operating model of financial institutions (Zhao Long, 2016); from the above four criteria, it can be found that industry players generally take profit as their primary consideration, so they pay more attention to cost than others. Customer information security and trust are also relatively essential factors for industry players.

3. Analyze the current transaction behavior and whether blockchain can effectively improve transaction security. In the old transaction behavior, paper documents were used for transmission. Recently, emails have been used for data network transmission, but information leakage still occurs. Alternatively, there are problems with mail being damaged and unable to be received, and there are often problems with information flow, logistics, and cash flow needing to go hand in hand.

If blockchain technology is used, all parties to the transaction will have reliable evidence of prosecution simultaneously (Evans, 2014). If a problem occurs, the responsibilities of each party will be clearly defined, thereby improving processing efficiency. Moreover, because the blockchain is a point-to-point transaction, the role of third-party intermediaries will gradually be replaced. Although email is currently used as the primary

method of data transmission, some documents can only be sent in paper format, and information asymmetry often occurs. Therefore, if blockchain technology is used, information asymmetry will be improved. Because the blockchain is peer-to-peer, as long as the primary endpoint sends a message, all endpoints can receive the message, and there is no need to worry about data loss or damage.

4. Currently, international logistics operators have yet to have complete contact with blockchain, and few international logistics operators are using blockchain technology. Therefore, if this technology is used early, it can prevent other competitors from catching up from behind, and it can also be used early To adapt to future trends; blockchain technology makes data transparent and non-tamperable and establishes an order trust mechanism (Wright & De Filippi, 2015). In previous transactions, those who did not trust information, in new types of transactions, the use of blockchain technology can not only allow information to be transmitted safely and error-free but also allow international logistics operators to improve transaction security.

Value:

The excessive use of paper documents was discovered as one of the reasons why the shipping industry lagged behind other industries, so it gradually turned to electronic transmission of information. Meanwhile, because transporting goods requires crossing different languages, laws, and organizations, The operation process is prolonged, and because the goods in these containers are usually collected from suppliers in different countries, using a unified electronic system will face challenges.

The international logistics industry is a logistics activity that sells products across borders. Therefore, international logistics operators will frequently contact business people from different countries. This study will explore this issue since each international logistics operator has a different perception of transaction security.

Research limitations/implications:

This study mainly focuses on Taiwan's international logistics operators. It is hoped that most international logistics operators will introduce blockchain technology and have more and safer payment channels for new transaction types and trade models. This payment channel does not require Transactions to be made with any trust mechanism, so we hope they will pay attention to the risks of transaction security and introduce a blockchain trading system to increase the industry's profits and security.

The international logistics industry in Taiwan still needs to formulate laws that regulate blockchain. However, in practice, if this technology is introduced, it will speed up the efficiency of services and transactions for international logistics companies. Shipping resources can be capitalized through blockchain and used in Digital format to facilitate transactions. Future research can be directed towards preparing relevant laws and regulations or researching the obstacles to using blockchain technology. In that case, it will significantly help the practical community and the government.

Practical implications:

For the risks mentioned above, operators should coordinate with the government on relevant laws and regulations and cooperate with the policies set by the government. This is because, during this interview with operators, they mentioned that although most documents are currently transmitted via email, on-board shipping Problems of incomplete or erroneous information transmission often occur between companies, shipping contractors, counters, and customers. If blockchain technology is used, all parties in this transaction can obtain correct and traceable electronic certificates. If one party makes a mistake, they can also know where the problem is and correct it in time.

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A Study on the Drone Stations

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Purpose of this paper:
The unmanned aerial vehicle (UAV), or drone, is emerging as an essential technology in various sectors, pushing the boundaries of technical innovation. Drone stations (DSs), in response to the growth of UAV technology, are also attracting attention. Drone station serves as vital location or facility, such as charging stations, drone delivery hubs, and an operational command centre for drone utility. These facilities are important because of their role in optimizing drone operations (e.g. efficient loading and unloading of products etc.) and ensuring longer flight times through efficient recharging, centralized control, and dependable communication links. However, despite the growing recognition of the value of drone stations, there have been few researches in the literature of drone station. The purpose of this study is to define and compare different types of drone stations, especially in the field of logistic, by their function and purpose and suggest a basic guideline for the design and operation of future drone stations.

Design/methodology/approach:
In this paper, through a literature review, we classified various types of drone stations according to their features, purposes, functions, and fields of usage and investigated the practical uses of these facilities. Focusing on the usage of drones in logistics, we also reviewed and compared drone stations that were proposed by several logistics companies.

Findings:
By performing literature reviews, we investigated drone stations that have been designed and are now in operation in logistics. We examined and contrasted the currently in-use drone stations with the ones that were suggested, comparing their similarities and limitations. Some of findings are: lack of efficient loading/unloading mechanism- how to feed cargo from warehouse or factory instead of manual loading; no-consideration of multiple drones' take-off and landing; lack of safety implications of drone stations in logistics.

Value:
This paper explores and classifies various types of drone stations, focusing on their practical applications in logistics. It provides insights into the evolving landscape of drone technology in the industry and emphasizes the importance of safety and efficiency of operation. The paper contributes to the discourse on integrating drone technology into logistics operations, providing valuable resources for academics, industry professionals, and policymakers interested in the practical applications and advancements of drone stations.

Keywords: Drone, Drone Station, Safety, Loading/Unloading

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Variation of map matching algorithms and corresponding purpose

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Purpose of this paper:

Global Navigation Satellite System (GNSS) is widely used in modern society. Global Positioning System is a popular instance of GNSS. GNSS is also used in transportation industry. Car navigation system is a typical instance.

Location data obtained from GPS trajectory of vehicles can provide benefits to logistics business such as more precisely estimation of arrival time or a suggestion of trouble on vehicle. Integrating with information about land feature, current meteorological data, loading goods, it becomes possible to estimate condition of vehicles without especially equipped sensors on them. The estimation will be utilized for not only preventing sudden trouble on delivery vehicles but also reduction of down time of delivery vehicles.

(Takeno and Inoue 2023) presented effect of geometrical and meteorological conditions on fuel consumption. They used GPS trajectories to estimate accurate position of vehicles. The process is called Map Matching where position on the map is estimated by GPS trajectories. There are several approaches and algorithms to realize Map Matching. In this paper, we present literature review for Map Matching Algorithms to explain relationship among purposes and methodologies.

Design/methodology/approach:

Digital Road Map is a graph comprised with vertex and edge which represents Road network in digital. Map Matching algorithm determines an edge, i.e. a road segment, as a position of a vehicle from a series of GPS trajectory.

Map Matching algorithms are classified into two categories: Dynamic Map Matching and Static Map Matching. Dynamic Map Matching estimates current position of a vehicle at the time, i.e. real time estimation. And it is applied in Car Navigation. Static Map Matching estimates a path, i.e. series of edges, from GPS trajectories. Past GPS trajectory is available to analyse with Static one. In this paper, we have focussed on Static Map Matching.

(Yu et al. 2022) present three categories of map matching method. The first one is methods based on machine learning. The second one is methods based on probability calculation. In this category, hidden Markov model is used to estimation. The last one is methods based on weigh assignment.

We have selected more than fifteen papers from Science Direct, Google Scholar and etc. Papers are categorised with purpose and algorithm of Map Matching.

Findings:

Many papers were retrieved from search engines with key words “map matching” and “GPS.” Most of them were papers that estimation and accuracy improving are conducted for buildings location from satellite images. We made an exception for papers in which position of road segment or buildings is not estimated from GPS trajectories.

Papers are classified according to purpose, algorithm and published year.

There is a wide range of variation in purpose of Map Matching. The purpose is not only estimating a road segment on digital road map, but also estimating volume of traffic in central city. Furthermore, we found a paper in which authors estimated currently available path from GPS trajectories because there were roads repairing.

There are quite different algorithms are proposed for Static Map Matching. One example is to estimate a path by using information about previously estimated path. Another example is that repeatedly exchange certain paths to improve fitness function starting from randomly assigned series of paths.

Value:

We present a variety of Map Matching Algorithms according to their purpose. This will support researchers selecting and understanding merits and demerits of the algorithms. Furthermore, combinations of algorithms may provide a new powerful algorithm.

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Development of Maturity Model for Digital Transformation

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Purpose of this paper:

Presently, the food supply chain (FSC) is the focus of attention due to various ongoing global events. Technological innovations are critical enablers in addressing various FSC challenges, including traceability issues (Ben-Daya et al., 2019), increasing needs for real-time information sharing (Belhadi et al., 2024), food loss and waste (Annosi et al., 2021), poor standards for food safety and quality control (Shukla and Jharkharia, 2013), as well as lack of coordination between different stakeholders (Mogale et al., 2020; Irani et al., 2018). However, the complexity of various types of emerging technologies often hinders companies from accurately gauging their digital maturity and understanding the associated benefits (Wang et al., 2024; Tortorella et al., 2023; Caiado et al., 2021). Acknowledging the transformative potential of Industry 4.0 technologies in the food industry, it becomes imperative to assess the current state of emerging technology utilisation in real-world FSC businesses (Kamble et al., 2020). Thus, the maturity model is regarded as a critical assessment tool to understand the level of digitalisation and improve the performance of operations.

Based on the various maturity models summarised, no research has been conducted to develop a maturity model for measuring digital transformation from a holistic view focusing on FSCs in particular. Few studies attempted to examine the maturity of a specific technology in FSCs. However, those relevant studies either focus on one exclusive emerging technology or on traditional ICT (Information and Communication Technology). Furthermore, compared to other types of supply chains, FSCs are different because of the perishability of the products (Shukla & Jharkharia, 2013), the requirement for more flexibility and agility owing to the short shelf life, the wide variety of products, and the high frequency of orders (Viet et al., 2020), as well as concerns about food integrity (Mangla et al., 2018). However, traditional maturity models may not adequately capture these specialised functionalities of FSCs. Therefore, there is a need for a new maturity model that covers the distinct requirements of the FSC and integrates the specific functions provided by emerging technologies.

This study aims to develop a digital transformation maturity model tailored for FSCs. The model seeks to evaluate the current state of technological implementation within FSCs, offering detailed criteria and serving as the foundation for upgrading digital maturity in the supply chain (SC) context.

Design/methodology/approach:

The qualitative study firstly develops a conceptual digital transformation maturity model for FSCs. The model is based on the Technology-Organisation-Environment (TOE) framework, the business process maturity model (BPMM), and the capability maturity model integration (CMMI). Subsequently, semi-structured interviews are conducted to gain insights from a diverse set of practitioners in the food industry to validate and improve the digital transformation maturity model. Following the theoretical sampling, thirty interviews were conducted between October 2023 and March 2024. Each interview lasted between 50 minutes and two hours. Follow-up interviews and email communication were scheduled to assist in answering unclear questions and providing further perspectives on the topic. All the interviews were recorded and then anonymously transcribed into a written document. Data analysis is built on three levels of coding: open coding, axial coding, and selective coding. The study ends with the evidence-based digital transformation maturity model that includes measurements for assessing digital transformation status covering different activities within the FSC.

Findings:

Through the coding and analysis of FSC stakeholder insights (comprising managers and technology service/solution providers), the maturity model is established as a matrix, horizontally and vertically divided by digital transformation dimensions and maturity level. Every element of the model contains a status description and possible improvement paths for different stages of digital maturity.

Critical triggers for implementing emerging technologies include food safety, quality, supplier management, efficiency improvement, real-time visibility, and transparency. The role of the Internet of Things (IoT), cloud computing, and big data analytics in data governance is highlighted, emphasising the importance of converting data into actionable information. It is observed that the digital transformation maturity extends beyond technological aspects, encompassing process standardisation and human factors. The study underscores the significance of a digital transformation mindset, commitment of the top management, aligned business processes, and skilled resources for ensuring successful digital transformation. To thoroughly enrich the evaluation criteria of digital transformation maturity, each element within the model matrix is detailed.

Value:

The study provides theoretical and practical contributions by establishing an evidence-driven digital transformation maturity model for FSCs. The model utilises the TOE framework to classify the three main dimensions for assessing digital transformation maturity, further elaborating on detailed sub-dimensions while considering the unique characteristics of FSCs. Furthermore, the model can be practically used as a method to assist FSC businesses in understanding their current digital maturity and guiding the development of their digital transformation roadmap.

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A Study on the Simulation based Digital Twin Model for the Warehouse Operation

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Purpose of this paper:
Due to the development of IoT technology, a Cyber-Physical System-based work environment which leads to digital twin implementation cases is getting mode intention in logistics industry. Despite the fast adoption of automation technology, most automation equipment is still operating based on traditional concept-simple standalone operation without understanding the overall flow and impacts among downstream and upstream equipment. The purpose of this study is to present a digital twin implementation model between a virtual warehouse implemented through a simulation that can be used in the automation transition process in a company and a real warehouse implemented.

Design/methodology/approach:
Reference surveys were conducted for digital twins and relevant technologies. Functional comparisons were conducted on SCM software to select target software to apply digital twins. Facilities for applying digital twins were selected and related research trends were investigated. External interface functions using warehouse modeling and simulation tool-Flexsim were studied, and a digital twin model was derived by conducting a study on open-source OPC/UA for interworking.

Findings:
Through literature and case studies, we found: the terms currently scattered; and the layer and role of each system through function comparison between SCM software were not clearly defined. To address the issues, we present a reliable model by presenting a plan to build a digital twin environment using open source and commercial logistics simulation programs. It is considered that our research provided a flexible model that can be implemented even if the interface part is replaced with another module.

Value:
In this study, we tried to find points that can apply Digital Twin in the logistics warehouse. In addition, by suggesting the establishment of a digital twin environment using Flexsim and open-source OPC/UA modules, we tried to secure reliability and reduce access to digital twin implementations.

Research Limitations/implications:
In this study, Flexsim and open-source OPC/UA models were presented, but there is weak introduction to implementation cases. In addition, since the OPC/UA module used in this study is open-source, additional reliability verification is required. Our future study is to actually implement and verify the model.

Practical implications:
We tried to establish and utilize a digital twin environment through the commercial simulation tool, using one of the most widely used tool in industry. Using this concept, various operation methods and work processes can be verified before implementation, and warehouse operation efficiency can be improved by minimizing waste of related resources.

Keywords: Digital Twin, Cyber-Physical System, Simulation

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Reducing systems uncertainty in the craft beer industry using IoT sensor technology: An explorative case investigation

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Purpose of this paper:

Complex, uncertain and constantly changing business environment, changes in customer demand patterns, and the need for supply chain flexibility are turning the spotlights to advanced technological innovations (Oberg and Graham 2016). Organisations are realising the strategic advantages that technology can offer when deployed effectively (Handfield et al., 2022). However, there is limited evidence of the approach being applied in practice across organisational boundaries (Agrawal et al, 2019). Many companies have already applied e-business technologies to reduce systems uncertainty via business process integration. These companies are now shifting their attention to Industry 4.0 technologies such as 3D printing, Blockchain, Artificial Intelligence and/ or Internet of Things (IoT) (Bhatia and Kumar, 2022). Fatorachian and Kazemi (2021) pointed out that Industry 4.0, as an operational outlook, has been mainly explored from the viewpoint of production/ operations in recent literature and less from a supply chain perspective. Given the increasingly critical role Industry 4.0 plays in supply chains, the purpose of this investigation is twofold; (i) explore the impact of Internet of Things (IoT) sensor technology on supply chain (systems) uncertainty reduction and ultimately on performance, and (ii) comprehending the reasons for limited digital transformation across supply chains. Here, the well-established uncertainty circle model by Mason-Jones and Towill (1998) was adopted to guide the investigation. The uncertainty circle model highlights four areas of uncertainty; namely supply, demand, process, and control uncertainty.

Design/methodology/approach:

This research approach is based on a single explorative case study (Yin, 2014) providing an opportunity to understand IoT sensor deployment practices and the development of theoretical insights (Ketokivi, 2006). Single case studies "enable the researcher to capture in much more detail the context within which the phenomena under study occur." (Barratt et al, 2011, p. 331). Through collection of data from the business owner, the management team and secondary sources, current and historical data was accrued (Miles and Huberman, 1994). The analysis of data was guided by the Uncertainty Circle Model framework. BinaryTech is an Australian organisation and the focal point of the investigation. BinaryTech is the global leader in smart keg technology, boasting numerous patents and a long list of "world first" accomplishments throughout their mission to connect the world's kegs to the cloud. BinaryTech has been deploying smart kegs since 2018 to improve the quality and profitability of craft brewers globally allowing this niche and growing artisan industry to track assets and monitor quality. Craft beers are preservative free and hence are more vulnerable to loss of quality through inappropriate handling of kegs in the beer distribution network. Craft beers are also predominantly consumed within the same geographical area where it is brewed. Handling of the kegs itself, exposure to high temperature and low volume while being on tab are all potential quality impact factors. Traditionally, craft brewers lose control over their kegs once dispatched to a venue leaving brewers with a high reputational risk. Binary Beer's smart keg sensors are equipped with 5G wireless connectivity and bespoke IoT sensors able to monitor key data points including location, temperature, tilt, and volume while identifying the exact moment when the beer is put on tap.

Findings:

IoT sensor deployment uncovers live, actionable insights from the distribution network that have historically been unavailable to craft brewers. The insights from the distribution network allow to enhance the sales and operational planning process, improve logistical routing and give control back to the craft brewers in regard to quality allowing the industry to protect its unique brand and reputation to their unique customer group. Mapping the various sensor technologies onto the uncertainty circle highlights the various impacts the technology has on reducing systems uncertainty. Even so the technology is deployed within the outbound logistics, the information collected and analysed by the sensor and associated data analytics software enables uncertainty reduction in other parts of the supply chain. Therefore, enabling digital transformation and integration across organizational boundaries (Angelopoulos et al, 2023). Table 1 provides an overview of the craft beer systems uncertainty reduction through massive IoT deployment.

Table 1: Systems Uncertainty Reduction through Massive IoT Deployment

Uncertainty Source	**Reduced through Massive IoT Deployment**
Demand	• Volume tracking using infrared laser sensors at the top of the keg • Time stamp when keg goes on tap using an infrared laser sensor
Control	• Asset tracking of beer kegs using a geo-location sensor • Quality control using temperature and tilt sensors
Process	• Information on volume per type of beer, in-house stock levels, location of venue and kegs per venue allow for S&OP processes in regard to batch prioritisation • Lead-time compression (production to distribution time) • Digital integration
Supply	• Sharing of S&OP planning data with upstream suppliers and 3PL companies for scheduling purposes

The initial rollout with craft brewer clients resulted in lead time compression. The average production-to-distribution time was almost quartered from on average 15 days to 4, with the slowest journey now measuring 8 days. This 74% reduction was achieved through comprehensive location mapping of breweries and distributors, enabling analytics to compare and optimise travel times across various transportation routes. Also, BinaryTech identified over 1,000 previously unseen sales outlets for craft brewers and tracked keg activity, including:

- Time to Tap: Measuring the duration between keg filling and consumption (tracking freshness and outlet performance).
- Time on Tap: Enabling comparison of keg consumption rates across different venues.
- Time off Tap: Enabling one-time keg collection routes to enhance logistics efficiency.

The latest development is a 'freshness score' for each keg based on its specific contents (e.g., beer type, alcohol content) and current environmental conditions (heat, tilt). This score, ranging from 100% (optimal) to 0% (significantly degraded), offers a holistic view of how each product fares throughout the supply chain. Real-time alerts proactively inform stakeholders of potential freshness issues, such as temperature deviations or extended keg inactivity at specific locations. This early warning system exemplified its value in a pilot project where an alert identified ~100 kegs (~3,000L) that had been stationary for over 5 months, exceeding their estimated shelf life. As a result, no full keg has remained at that site for longer than 8 weeks since the incident. This significantly reduced freshness risks and associated waste.

Value:

This is one of the early investigations that explore the impact of tailored IoT sensor technology on systems uncertainty reduction, overall supply chain performance and digital integration. Hence, the major contribution of this research are; the novel insights into digital integration across organizational boundaries through collaboration and sharing of digitalization experience between partners, and how IOT supports commercially orientated craft brewers to reduce uncertainty and improve supply chain efficiency. Efficiencies occur predominantly through lead-time compression and logistical routing. However, the technology further allowed craft brewers to monitor overall product quality throughout their distribution network and hence monitor and control their unique value proposition to their niche but growing market segment.

Research limitations/implications:

This single case study investigated the early adoption of IoT sensors technology in a very particular context. Further research needs to be conducted to identify if similar impact on systems uncertainty and supply chain performance can be achieved. Further, the deployment of IoT upstream along the entire supply chain is of interest to explore other benefits beyond quality and efficiency.

Practical implications (if applicable):

IoT sensors when deployed within the supply chain has the potential to drive business improvement beyond efficiency and deliver multiple benefits. IoT sensor technology can provide a vast range of information and managers need to identify what type of information yield the greatest impact when aiming to manage and control their value proposition to their customers.

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Socio-technical Regimes for Additive Manufacturing

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Purpose of this paper:

Since its introduction into low-volume production, academics and practitioners have debated the potential for Additive Manufacturing (AM) to emerge from its niche status to replace traditional manufacturing (TM) methods (Holmström *et al.*, 2016). A lot of scepticism has surrounded this prospect, with most scholars conceding that AM will play a complementary role in industrial Supply Chains (SCs), by supporting low-volume production (Braziotis *et al.*, 2019; Sandström, 2016; Sasson and Johnson, 2016). This expectation appears plausible as the majority of reported applications have been in the low-volume region (Jimo *et al.*, 2022), with very few high-volume applications (Huang *et al.*, 2021). That said, significant uncertainty still remains about the long-term sustainability of AM as a complementary manufacturing technology in industrial SCs. Several AM implementation barriers have been reported over the past two decades (Choudhary *et al.*, 2021; Hopkinson and Dickens, 2003) and some are due to the incompatibilities of the emerging technology with existing institutions in industrial SCs. Institutions here refer to common habits and rules that structure human interaction and bring stability to societal systems (Geels, 2002; Scott, 2013). In the context of AM, institutions are the shared regulations, routines and norms that structure social behaviour to reduce uncertainty and solve industrial problems. However, an understanding of the nature of these institutions and their implications for the sustenance of AM as a complementary manufacturing method in the long-term is lacking. Using the concept of socio-technical regimes, this paper explores the state of institutions in the AM context and analyses future potential of the technology for industrial applications.

Design/methodology/approach:

Using socio-technical theory (Geels, 2002) as a lens, this paper analyses 18 industrial applications of AM in Aerospace, Automotive, Power Generation, Marine and Rail sectors, focusing on the production of end-use components. The applications involved production of low-volume components for product assembly and maintenance repair operations. A qualitative approach, involving semi-structure interviews, was adopted to explore implementation related issues in the context of AM. A series of 25 semi-structured interviews were conducted in-person and online in the UK, Germany, the Netherlands, India and the USA. Respondents were asked to explain the reasons for adopting AM for producing end-use components and identify the challenges they faced during implementation. A semi-structured interview format was adopted to elicit rich accounts from respondents regarding implementation challenges faced at different stages of the production process including design, pre-processing, production and post-processing. The interviews were voice-recorded, transcribed manually on NVivo Pro 12 and coded deductively using rule categories from institutional theory (Scott, 2013). Thematic analysis was applied to identify prevailing AM implementation-related themes with respect to specific industrial applications in specific participating organisations (Braun and Clarke, 2006). Themes were generated during the analysis and coded into regulative, normative and cognitive nodes in NVivo Pro 12 and reviewed successively for consistency. This process facilitated the identification and analysis of dominant themes across interview respondents.

Findings:

Our analysis exposed the sense of discontent amongst AM adopters regarding the limitations of Traditional Manufacturing (TM) at different stages of the manufacturing lifecycle. This gap has created a window of opportunity for AM with its promising capabilities, which are influencing adoption decisions amongst manufacturers. However, various institutional issues have been crystallising in AM SCs during the implementation process in regulative, normative and cognitive terms for adopters. Our analysis shows a significant lack of knowledge and historical data on the performance of AM processes, leading to reduced adoption confidence and suggesting a cautious approach to adoption. There are also gaps in the understanding of customer requirements and AM capabilities. These knowledge gaps and uncertainties negatively affect the stability of cognitive rules in terms of production and design, which need to be shared commonly amongst engineers and designers in the AM community. Significant gaps also exist in post-processing methods designed to cope with the infinite variety problem posed by AM, agile strategies to manage low volumes in the upstream section of manufacturing SCs, as well as quality management procedures. These deficiencies increase uncertainty and instability of normative rules in the AM niche. The regulative dimension also faces significant deficiencies in terms of process and material standards and qualification procedures. The temporal instability in the manufacturing socio-technical regime, which is dominated by TM technologies has created a window of opportunity for AM. However, its ability to become a problem solver and gain an established state in mainstream manufacturing is dependent on the speed with which stability can be brought to rules that govern its operation. Stability and coherence amongst regulative, cognitive and regulative dimensions are prerequisites for establishing AM as a dominant complementary technology in the socio-technical regime . The stability of the cognitive, normative and regulative rules governing AM is likely to be achieved in collaboration with the dominant TM socio-technical regime because of their interdependencies.

Value:

This paper fills a gap in the AM implementation literature by identifying institutional factors militating against the long-term viability of AM as a complementary manufacturing technology. These institutional factors are foundational predictors of innovation's success, an insight that is missing from extant AM implementation literature. These insights are important for all stakeholders in the AM ecosystem, particularly policy makers to inform development initiatives, strategies and resource allocation for industry.

Research limitations/implications:

Our analysis was limited to industrial applications in Aerospace, Automotive, Transportation and Power generation sectors. Future research could cover the state of institutions and rules in other sectors, such as medical, where adoption levels are growing. Research is also required to investigate the state of niche processes, i.e. voicing expectations, network formation, experimentation and learning to investigate how stability will be brought to the identified rules in the AM context.

Practical implications :

This article draws attention to the importance of institutions and rules in the overall stability and sustenance of an emerging innovation. Insights are useful to stakeholders and policy makers in the AM eco-system to inform the design of networks, pilot projects and experiments to develop rules that support the co-existence of complementary technologies.

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Advantages and Limitations of Using Virtual Reality for Training and Examining the Quality of NDT Processes in Logistics and Production Operations

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Purpose of this paper:

Damage to goods and material are significant issues within production and logistics operations [1]. In- and out-stocking, material movement, picking, assembly etc. where we know such damages arise. Some of these damages are caused by improper handling of the material and goods, and even if well-packaged it might be damaged by small chocks, too fast acceleration, continuous vibrations etc. [2,3], other damages may arise during the production process, if the process is not carried out as it needs- examples of this is coating and welding processes, where a specific operation needs to be carried out with a specific speed and pressure in order to achieve optimal result [4].

Depending on the material and the goods, damage to the structure caused by improper handling might be difficult to detect, but a typical testing method is the non-destructive testing (NDT) [4,5]. Nondestructive testing (NDT) is group of analysis techniques used evaluate the properties of a material, component or system without causing damage [6] and due to the nature of the techniques, it may save both money and time in product evaluation, troubleshooting. However, the quality of the NDT process (i.e. to operate the different techniques) correctly requires a well-skilled workforce, and therefore it is necessary to train the operators involved in these processes regularly [7,8]. This training is both costly and time-consuming, and often requires that the employees travel to specific training centres. In this work we therefore examine if it is possible to use virtual reality instead. The idea, which is still only conceptual, is to embed such a VR training environment in a lab setting. The work is based on previous projects we have had on VR, virtual labs and living labs [9,10, 11]. At the current state we have only analysed the previous experience and defined the requirements. A first mock-up of the environment is expected late autumn 2024.

Design/methodology/approach:

We used action-based research for the system requirement and the conceptual design of the gamified environment. The design of a virtual gamified NDT environment is a demanding operation, given the complexity of the resulting system and the difficulties in efficiently measure the interaction between the system and the user. To identify which of the techniques that might be possible to map and mirror in a virtual environment, it is important to understand the processes. The NDT and welding experts in the consortium did therefore a first analysis and prepared a draft on selected processes including a detailed description of critical moments within the process. Furthermore, we also analysed the observations we had on training warehousing operations in a virtual environment. The virtual reality environment focused particularly on the handling of materials and goods in operational logistics processes and was therefore considered to be suitable as a starting point in terms of investigating user- system interactions [12]. The virtual reality environment with playful components has been developed to facilitate the understanding of operational processes such as order picking, as well as to practice storage and retrieval processes and to deepen the relevant process and technical skills.

The evaluation of that VR environment showed that usage contributed to a good understanding of the picking, storage and retrieval processes of materials and goods, but required a lot of practice before the processes could be carried out error-free. Pictures of the analysed environment is shown below (see Figure 1)

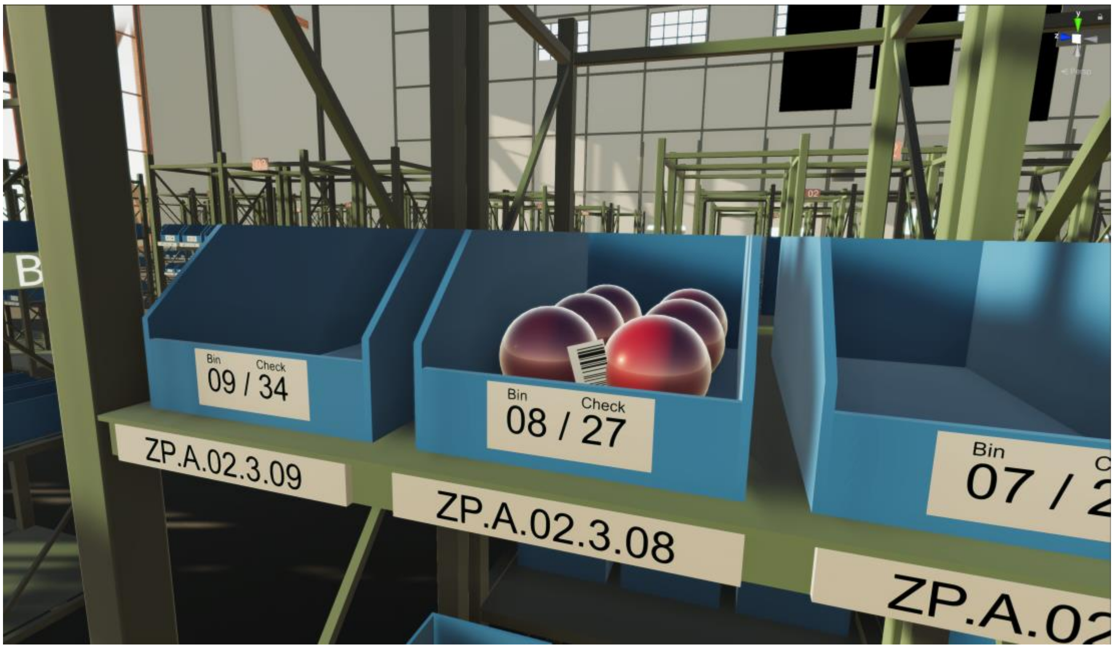

Fig. 1 Virtual environment for training picking and kitting operations.

Embedded in different teaching units, the VR prototype offers a variety of possibilities to address the individual needs of the participants. However, the analysis of human-computer interactions has shown that good hand-eye coordination is required, and that the environment does not currently meet the requirements for inclusive design, thus limiting usability in some cases.

The selection of a set of NDT processes to be modelled as well as the learnings from the VR environment will be discussed at our next project meeting, on July 2 and 3.

In parallel, the gaming experts started the requirement analysis of possible software and hardware, carrying out a market search and matching with the skills of the developers. This analysis is completed and presented in the next section.

Findings:

The requirement analysis of the hardware and software that are needed in order to realise the envisaged NDT environment is summarised below. A more detailed specification can be found in [13]

Hardware

- *Interactive Touchscreen Board*

The interactive touchscreen board is a fundamental tool for developing the VR platform and application. It will enable us to visualize, manipulate, and control the digital models of the parts being tested, and to create a user-friendly interface for the application. The interactive touchscreen board will allow us to interact with the 3D models, perform digital testing, and provide real-time feedback on the results of the NDT testing. This technology will streamline the testing process, reduce testing time, and increase the accuracy of results by giving the teacher the possibility to actively interact with the students who are online. Moreover, the interactive touchscreen board will also enhance the user experience by providing a more engaging and interactive environment for the testers. It will enable them to navigate and manipulate the 3D models, making it easier to identify defects and perform inspections.

- *VR Headsets*

When considering VR headsets for integration with the Unity 3D game engine and interactive touchscreen board, several critical factors should guide the selection process.

Firstly, the display quality of the VR headset is paramount for delivering an immersive experience. Opting for headsets with high-resolution screens, such as those with higher resolutions, ensures crisp visuals and minimizes the "screen door effect," where visible gaps between pixels can detract from immersion. Additionally, a high refresh rate, ideally, contributes to smoother motion rendering, reducing the likelihood of motion sickness and enhancing overall comfort during extended use. Accurate and reliable tracking technology is essential for enabling seamless interaction within the virtual environment. Inside-out tracking systems, which utilize onboard sensors to track the user's movements without the need for external sensors, offer convenience and flexibility. However, for applications requiring precise positional tracking, such as in-depth NDT liquid penetrant testing scenarios, external sensor-based tracking systems may be preferred for their higher accuracy. Comfort is another crucial consideration when selecting VR headsets. Models with ergonomic designs, adjustable head straps, and ample cushioning ensure a comfortable fit for users of varying head sizes and shapes. Additionally, features such as lightweight construction and balanced weight distribution help minimize fatigue during prolonged VR sessions, enhancing user comfort and immersion. Connectivity options and compatibility with the game engines such as Unity 3D game engine and the interactive touchscreen board should also be carefully evaluated. Headsets offering seamless integration with Unity's development environment and robust support for industry-standard VR development frameworks ensure a smooth workflow and efficient development process. Moreover, considering compatibility with the interactive touchscreen board ensures cohesive integration between hardware components, facilitating interactive user experiences and enhancing overall functionality. Furthermore, audio plays a crucial role in creating a fully immersive VR experience. VR headsets equipped with integrated or detachable audio solutions, such as built-in headphones or audio jacks for external headphones, provide spatial audio cues that enhance immersion and realism. Selecting headsets with high-quality audio reproduction capabilities further enhances the overall VR experience, allowing users to fully immerse themselves in the virtual environment.

- *VR Controllers*

The selection of VR controllers depends on various factors such as compatibility, functionality, and user experience. For the development of a VR platform, there should be consideration of using controllers that offer a balance of features, performance, and compatibility with the proposed VR hardware and software.

Software

- *Unity 3D Game Engine*

Unity Game Engine is the reliable choice for making virtual reality (VR) experiences because it has many features designed specifically for creating immersive VR worlds, including: (i) Unity's high-definition render pipeline (HDRP) and universal render pipeline (URP) offer sophisticated rendering capabilities, enabling developers to achieve reliable visual fidelity in VR environments. With support for advanced rendering techniques such as physically based rendering (PBR), and high dynamic range (HDR) rendering, Unity empowers developers to create lifelike VR experiences with unparalleled realism. (ii) Unity's Shader Graph and Visual Effects Graph provide intuitive, node-based interfaces for creating custom shaders and visual effects in VR applications. Developers can leverage these tools to achieve complex visual effects, such as dynamic particle systems, volumetric lighting, and shader-driven animations, enhancing the visual richness and interactivity of their VR experiences. (iii) Unity's XR Interaction Toolkit offers a comprehensive framework for implementing VR interactions and locomotion mechanics. From hand presence and object manipulation to teleportation and smooth locomotion, developers can leverage the XR Interaction Toolkit to create intuitive and immersive VR interactions that enhance user engagement and presence within virtual environments. (iv) Unity's built-in physics engine provides robust simulation capabilities for accurately modelling physical interactions within VR environments. With support for rigid body dynamics, collision detection, and constraints, developers can create realistic interactions between virtual objects and users, facilitating natural and intuitive interactions in VR experiences. (v)Unity's multiplatform support allows developers to target a wide range of VR devices, including head-mounted displays (HMDs), standalone VR headsets, and mobile VR platforms. With built-in support for platforms such as Oculus Rift, HTC Vive, PlayStation VR, and Oculus Quest, Unity provides a unified development environment for creating VR experiences that can reach a diverse audience of VR users. (vi) Unity offers a suite of performance optimization techniques to ensure smooth and responsive VR experiences. From occlusion culling and level of detail (LOD) systems to asynchronous reprojection and dynamic resolution scaling, Unity provides developers with tools to maximize frame rates, minimize latency, and optimize resource usage in VR applications. (vii) Unity's powerful scripting API and extensibility features allow developers to extend the functionality of the engine and create custom VR solutions tailored to their specific requirements. Whether it's integrating external SDKs, implementing custom locomotion mechanics, or developing AI-driven behaviours, Unity provides developers with the flexibility and control needed to realize their VR experience.

As described in the method and approach section, the time to learn how to use the application as well as the natural user interaction with the system are essential for the success of any training activity. We have therefore focussed on the following aspects. More details can be obtained from [13]:

- Visualization and Interaction with 3D Models
- User-Friendly Interface Creation
- Real-Time Feedback and Interaction
- Engaging and Interactive Environment
- Flexibility for Scenario Design
- Streamlined Development Process

Development tools

Regarding the VR development tools and SDKs (Software Development Kits) we have identified the following requirements: the tools need to provide APIs (Application Programming Interfaces) for interfacing with VR hardware, implementing input controls, optimizing performance, and integrating additional features such as spatial audio and multiplayer networking

Value:

Non-destructive testing plays a vital role in ensuring that the delivered material and goods fulfil the customers' needs and expectations. The quality of the manually carried out process, depends highly on the skills of the operator. Therefore, the literature emphasizes on the need of regularly training. This training is both time consuming and costly. A virtual training environment for some of the required techniques can help in reducing the cost as well as overcome the challenge of having to send away the employees to specific training centres. However, the presented research will first need to develop testable prototypes to be verified and validated by the field experts. This is necessary in order to deliver proof of concept as well as for delivering an impact to the industries using NDT as a part of their quality assurance.

Research limitations/implications:

The work on using VR not only for training but also for evaluating the process quality.

Practical implications:

The envisaged technical solution will need to be tested, verified and validated before the practical implications can be derived.

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The content is solely in the responsibility of the authors

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Digital Platforms in Supply Chain Management: A Systematic Literature Review

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Purpose of this paper:

Known for their power to facilitate value co-creation, digital platforms (DPs) have made inroads into an extensive range of supply chain (SC) and logistics operations in recent years (Liang et al. 2021). DPs integrate logistics processes, boost quality and sustainability performance, and support Industry 4.0 integration into SC operations (Ruggieri et al. 2018; Alyavina et al. 2022). The imposition of lockdowns and physical distancing during the COVID-19 pandemic have further hastened the use of DPs to build new business models and expand market reach (Kam and Rimmer, 2022), leading to a spike in academic research on DP in supply chain management (SCM).

Several literature reviews have been conducted to investigate how DPs have been used in SC and logistics management. These reviews either focus on how specific DP technologies have impacted SC operations (Ben-Daya et al. 2019; Li et al. 2023) or investigate how digital technologies have supported DP development in SC and logistics (Büyüközkan and Göçer 2018; Núñez-Merino et al., 2020). There is a lack of systematic literature review (SLR) studies on how DPs are used in SC digital transformation and what issues and challenges have emerged in using DPs in SCM. We address this issue by conducting a SLR on the use of DPs in SC, asking two questions:

- What roles have DPs played in supply chain and logistics management?
- How can DPs be leveraged to fortify supply chain and logistics performance?

Methodology:

We employed Tranfield et al.'s (2003) SLR protocol and followed the PRISMA guidelines (Moher et al. 2015) to analyse the academic literature on DPs in SCs. We commenced our SLR by conducting a search on the Scopus database with the keywords "digital platform" or "cloud platform", and "supply chain" or "logistics" or "transport" being present in either the title, or keywords or abstract. All academic journal articles published in English, including "article in press", fitting the combination of the search terms are extracted. We then checked the Scimago database to exclude all non-Q1 ranked journals, followed by a review of the abstracts to assess the relevance of the identified papers. This process resulted in 58 papers being selected for full reading. After full reading, 50 articles, published between 2006 and 2023, were retained for our SLR exercise.

We conducted an inductive analysis of the 50 articles selected by analysing their contents, paying specific attention to the study focus or objectives, the findings and their implications. We followed the data categorization framework of Grodal et al. (2021) to make sense of our analysis and achieve rigor, classifying the 50 papers into four clusters, each of which representing a specific role DPs play in SCM. While several papers could potentially be interpreted to fall into more than one cluster, we decided to employ a mutually exclusive categorization, based on the thrust of the paper. However, we also recognize the value of the alternative interpretations, utilizing them to establish linkages between the clusters, leading to the development of a conceptual framework that helps us understand the relationships between the four identified roles.

Findings:

Our inductive analysis (still ongoing) of DPs' contributions to SC operations and management identifies four key roles, which we label as operations facilitator, solution incubator, performance booster, and mission-specific solution provider. Articles in the first cluster (operations facilitator) focus on how DPs, through their integrated IT infrastructure, offer a hub or touchpoint for SC entities to conduct their business transactions efficiently and effectively without the conventional hindrance faced by the physical SCs, such as the need for intermediaries, or an explicit contract. In addition, these papers also examine the pre-requisites leading to successful value co-creation between users as well as impacts, both positive and negative, spawning from interactions between users and between users and the DP.

The second cluster of papers (solution incubator) concentrate on exploring how DP's integrated IT infrastructure could be leveraged to produce a range of solutions to support common logistics and supply chain operations, such as horizontal collaboration in road freight transport, and making private information sharing between supply chain partners a mutually beneficial option to eliminate information asymmetry and misinformation.

The third cluster of articles (performance booster) demonstrate the various ways in which DPs could contribute to improving performance in different supply chain operations: as driver, moderator, mediator, promoter, or enhancer. Some of the papers, however, explore the transaction thresholds that sustain DP profitability.

The last cluster comprises papers that look beyond leveraging DP's integrated IT infrastructure to develop solutions for common supply chain operations. These papers investigate how the DP ecosystems could be harnessed to produce solution that serves the needs of a specific industry, such as real-time spare parts inventory management in the mining industry, or those of a specialized operation, such as detecting disruptive impacts of Industry 4.0 technologies on the pharmaceutical circular supply chains to develop appropriate intervention strategies and solutions. We term this role mission-specific solution provider.

Through the implications of the findings culled from papers that could span multiple clusters, we establish the relationships between the four identified roles, developing a conceptual framework to tie them together for theory building and answering our second research question: How can DPs be leveraged to fortify supply chain and logistics performance?

Value:

Our SLR has three major contributions. First, we synthetize the key roles DPs play in supporting, driving, and shaping SC operations, producing a typology of DPs' roles in SCM. Second, by synthesising the findings' implications, we produce an integrated framework to show how the identified roles are interrelated to engender performance outcomes in SC operations. Third, we present an agenda for future research, taking into consideration the anticipated, continued domination of DPs as a business model in steering SC operations under the ecosystems of Industry 5.0.

With the astronomical rise of artificial intelligence and its embedment into a vast array of supply chain and logistical processes, the roles DPs could play in SCM are expected to expand. This SLR is considered timely: we provide a state-of-the-knowledge in the concerned literature where obvious gaps could be discerned and fruitful directions for further exploration could be undertaken to guide the development of DPs to support SCM.

Research limitations:

Being a SLR paper based exclusively on academic articles meeting our search criteria and published only in Scimago Q1 journals, there is always the possibility that some key papers on the topic could have been missed. Future research would certainly benefit from a wider search using less restrictive criteria.

Practical implications:

Since the advent of COVID-19, supply chain competitions have been increasingly contested on both the physical arena and digital space, where DPs play a critical role in linking the two. Understanding the roles DPs could play in supporting, driving, and shaping SC operations would help shed light on the possibilities DPs could offer to expand the scope of activities in the supply chain and logistics industry. Such understandings could also help SC entities to plan, schedule and orchestrate their logistical operations in ways that meet their resource budgets and satisfy their clients' needs simultaneously.

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Supply Chain Analytics

Blockchain Adoption for Electric Vehicle Batteries Reverse Logistics: A Total Interpretive Structural Modelling Approach for Barriers Analysis

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Purpose of the paper:

End-of-life (EOL) management of electric vehicles lithium-ion batteries (EVs-LIBs) has become a vital part of circular economy practices, especially in the European Union (EU)(Azadnia et al., 2021). Consequently, manufacturers must develop EOL management of EVs-LIBs through reverse logistics (RLs) activities. To implement effective RLs, there should be proper and transparent relations among the supply network members. In this outlook, blockchain is a cutting-edge technology that is already transforming and remodelling the relationships between all members of logistics and supply chain systems(Biswas et al., 2023; da Silva et al., 2023). The adoption of blockchain technologies into EVs-LIBs can provide safer, more transparent, traceable, and efficient transactions among the supply network members. In addition, blockchain adoption can enhance customers' trust as transparency and traceability can be improved(Ghadge et al., 2023). However, the adoption of blockchain technologies into EVs-LIBs RLs activities has many barriers and obstacles that need to be analysed and addressed. This study aims to develop a comprehensive hierarchy model of barriers to blockchain adoption in EVs-LIBs RLs activities. To do this, a comprehensive list of barriers to blockchain adoption in EVs-LIBs RLs activities is identified using a three-phase methodology. Then, the interrelations between the identified barriers are determined and analysed.

Design/methodology/approach:

The proposed methodology encompasses three main phases detailed in the following subsections. Phase 1 is about identifying barriers to blockchain adoption in EVs-LIBs RLs activities. To do this, initial barriers are identified through a literature review. Afterwards, a Delphi method is conducted to identify the finalized list of the barriers using EU experts' opinions. A purposive sampling is used to select the most relevant experts. The experts must have at least five years of experience in the area of blockchains and EVs-LIBs RLs. Structured interviews are used to gather data in the first and second phases. Firstly, a list of identified barriers with their description is given to the experts while asking them to give their opinion about the relevancy of the barriers and add more barriers that they think could be important but not in the initial list. The outcome of this iteration is analysed and an updated set of barriers is shared with the experts again to provide their opinions. This iterative approach continues until there is no change in the list. In phase 2, a Total Interpretive Structural Modelling (TISM) approach is utilised for identifying and interpreting the interrelationship among the identified barriers. In phase 3, the identified barriers are classified using the Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) technique.

Finding:

Based on the results of phase 1 of this study, eight categories of barriers to blockchain adoption in EVs-LIBs RLs activities were identified which are lack of support from management and organisational challenges, data privacy and security, lack of supportive policy and regulation, technological infeasibility, lack of cooperation between supply chain partners, lack of standardization and interoperability, high investment, lack of knowledge and expertise, environmental impact of blockchain technologies. Afterwards, using a TISM a hierarchy model was constructed. The hierarchy model includes 7 levels where technological infeasibility and environmental impact of blockchain technologies are located in level 1 and lack of knowledge and expertise are located in level 7. The results also revealed that lack of supportive policy and regulation, high investment, and lack of

knowledge and expertise are the driving barriers and data privacy and security are the most dependent barriers to the adoption of blockchain technologies in the EVs-LIBs RLs. The TISM models revealed the interpretation of the direct and indirect relationships between barriers too. Based on the MICMAC analysis, a few barriers such as lack of support from management and organisational challenges, and lack of standardization and interoperability were identified as linkage barriers. This means that any strategies to deal with these barriers will impact other barriers.

Value and practical implications:

Although several studies have been accomplished to analyse the barriers to blockchain adoption in various industries, none has considered such analysis for the EVs-LIBs manufacturing sector. This study establishes the groundwork for future investigations into implementing blockchain technology for EVs-LIBs RLs activities. This is particularly relevant as European Union legislation on the circular economy now requires all automobile manufacturing businesses to address their EOL wastes. The developed TISM hierarchy model provides a good understanding of the current barriers and their interrelationships for EU policymakers and practitioners. In addition, the clear interpretations of the interrelationships provide insights for developing further strategies to deal with these barriers.

Research limitations:

There are always limitations and avenues for future work in all research activities. There could be a great opportunity to integrate statistical models with the TISM and MICMAC to analyse the barriers and their interrelationships. This can help justify the barrier selections and linkage analysis by defining an effective threshold. There are a few good mathematical models such as Multi Mean De-Entropy for minimising the subjectivity in threshold selection. Given the circumstances we used structured interviews for conducting the Delphi method, it was very time-consuming and 20 experts were interviewed. The TISM model cannot provide ranks of the barriers. There is a good avenue of research to integrate stochastic or fuzzy decision-making models along with TISM.

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Development of Location Determination Model for Electric Vehicle Fast Charging Stations

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Purpose of this paper:

Climate change is a global issue nowadays. The carbon emission from human activity such as combustion of fossil fuels is increasing. Therefore, Electric Vehicles (EV) is one of strategic solution to tackle these concerns, due to their environmentally friendly properties, such as lowering emissions (Kchaou-Boujelben, 2021). However, the increased demand for EVs requires a fast charging infrastructure, which is essential to make a transition toward a sustainable transportation system (Kumar et al., 2022). The availability of charging infrastructure is a significant factor in the strong motivation of drivers to adopt electric vehicles.

This study proposes a location determination framework namely "Tri-Phase Model". To determine the suitable location for deploying Electric Vehicle Fast Charging Stations (EVFCS) in gas station. They are determined for dual purposes: first, to ensure that the EV network provides complete coverage from all points on the network, with provide more accessibility. Second, to integrate with existing facilities effectively so that available resources are utilized to a maximum. The study aims to develop a strategic framework to provide sustainable network for the development of EVFCS. Consequently, the objective of this investigation is to ensure adequate charging stations for EV adoption. This will alleviate the anxiety that EV users experience regarding the restricted range of their vehicles.

This framework, "Tri-Phase Model", includes three phases of methodology. By integrating multiple methodologies to identify the most optimal locations for EVFCS in existing gas stations. The first phase (Optimization) is a screening phase to determine a suitable location for placing Fast Charging Station (FCS) with the purpose of path coverage target and proper number of modules. The Multi-Period Arc-Cover Path-Cover Model (MACPC), proposed by Zhang et al. (2017), is applied in this phase to minimize the number of FCS and provide comprehensive coverage of the highway.

The second phase (Evaluation) is delved into the location which is an output from Optimization phase. This phase is employed to assess an existing gas station that appears in optimization node with a radius buffer. The objective of this phase is to investigate a convenient and accessible gas station to deploy FCS. Therefore, the Freeway Traffic Capture Method (FTCM), proposed by Kelley (2017) with integrating of framework of multi-stage proposed by Zhao et al. (2019) is applied to evaluate an existing gas station for deploying EVFCS. Finally, Selection, the LDT is implemented to determine the most suitable gas station. This is to ensure selected locations will work towards meeting not only the current demand but also expanding regarding increasing demand in EV growth.

This study provides a finding to locate EV-charging network toward sustainable transportation goals. The purpose is to design a structure that satisfies the uniqueness of the geography and socio-economic condition. It is predicated on data of EV adoption at various levels, as well as functioning infrastructure and available traffic flow data. It ensures a model that is methodologically robust and flexible to adjust for future technological advancements and demand fluctuations, as well as a strategic framework for the deployment of EV fast charging infrastructure. This study was able to provide an overall solution for supporting sustainable transportation, thereby facilitating the transition to a low-carbon economy, by optimizing the deployment of EV charging stations in the next periods.

This study proposes the Tri-Phase Model to locate the EVFCS along highways, in perspective of long-distance travels. Methodologies were proposed to locate the most suitable gas station that meets the demand of EV. This framework can identify a gas station that appropriately deployed FCS. Further, the research finding suggests a strategic approach to charging network deployment that significantly enhances the travel usability of EVs over long distances. The approach will reduce range anxiety and facilitate the user of EV toward national sustainability goals.

This framework is integrated with MACPC, FTCM, and LDT, to identify the optimal location of EVFCS. The approaches employed to address the development of EV charging infrastructure. The model ensures an optimal coverage route, strategic integrations with existing infrastructure, and future scalability in other regions. Concurrently, the results offer in two dimensions. First, policymakers, city planners, and stakeholders in the EV ecosystem valuable insights and establish a strategic framework for future deployments in regions. The findings have the potential to be beneficial in the design of policies and the planning of infrastructure investments. Second, contribution to academic, other researchers can utilize and modify this framework for future study.

Research Limitation:

The Tri-Phase model is essential for determining the suitable location based on the criteria that satisfy the requirement aspects. However, it is necessary to ensure the methods employed during the various phases are the most effective in addressing the underlying cause of the issue. Each phase would necessitate the continuous re-definition and modification of the models that were chosen to accommodate the underlying issues.

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Sustainability in Logistics and Supply Chains

Firms leveraging sustainability-driven change: evidence from a second-tier region in Mexico

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Purpose of this paper:

Through the theoretical lens of Dynamic Capabilities (Teece et al., 1997), this research aims to identify the benefits that companies situated in a second-tier region of Mexico, an emerging economy, have experienced by implementing their programmes for sustainability, and the mechanisms that have facilitated these benefits. Specifically, this research is guided by the question:

how do firms in a second-tier region in Mexico capitalize on the implementation of their programme for sustainability?

This paper defines a programme for sustainability as the set of individual strategies/interventions for sustainability implemented in a firm.

Previous research has found a disconnect between initiatives for sustainability and strategic management at the organisational level, resulting in unsuccessful attempts or outcomes that are far from the intended goals (Amini & Bienstock, 2014; Chowdhury et al., 2015; Engert et al., 2016). This gap can be worsened when the context for adoption of strategies for sustainability presents unfavourable and challenging conditions, such as that of emerging economies. Countries in this category are often riddled with issues such as lax environmental regulation (Chowdhury et al., 2015; Hossain et al., 2012), failure enforcing law compliance or its arbitrary application (Dobers & Halme, 2009; Hossain et al., 2012; Montiel & Husted, 2009), limited financial resources (Arevalo & Aravind, 2011) and poor infrastructure (Arevalo & Aravind, 2011; Hart, 1997; Silvestre, 2015). For companies in such contexts the endeavour of adopting programmes for sustainability becomes more daunting, and yet they are expected to comply with the sustainability mandates and policies of their business partners located in developed economies. Despite this scenario, the adoption of sustainability in organisations located in emerging economies has received limited academic attention (Bezerra et al., 2020; Dobers & Halme, 2009; Silvestre, 2015). Even less attention have received organisations located in Latin America (Amui et al., 2017; Bezerra et al., 2020) even though this geographical region is characterised as a major supplier of raw materials and minerals, and increasingly manufactured goods, to global supply chains.

There is also scarcity of literature on the adoption of programmes for sustainability from the perspective of second-tier regions. Located outside the country's capital and its metropolitan area, second-tier regions' economic and social performance have the capacity to impact the performance of the national economy (Parkinson et al., 2012, 2015). Yet, second-tier regions are more likely to experience limited infrastructure, access to services that favour greener operations, and lack of expertise than their first-tier counterparts. Notwithstanding, their role in connecting urban and rural areas (van der Gaast et al., 2020) and in achieving sustainable economic and social development (Agnoletti et al., 2015; van der Gaast et al., 2020) has been noted by scholars.

Scholars have also pointed out the lack of empirical research focusing on the elements that help conduct sustainability initiatives from its design to its implementation (Galpin & Whittington, 2012). This study aims to fill this gap by exploring and identifying the Dynamic Capabilities (DCs) (Teece et al., 1997) that have supported the implementation of programmes for sustainability, focusing on the benefits they have brought to companies. Furthermore, this research acknowledges the uncertain environment and paradoxical demands that companies face when implementing their programmes for sustainability (Porter, 2008; Vildåsen et al., 2017; Wu et al., 2013), which can exacerbate the difficulty of this task but can also help companies develop and enhance their ability to cope with these challenging conditions.

Methodology:

This qualitative study conducted a multiple case study on five large companies located in the Yucatan peninsula, a second-tier region in Mexico. Case companies were selected if they were accredited as socially responsible or had sustainability as one of their business guidelines. Selected companies operate in the industrial & mining sectors, specifically in the food and construction industries.

Semi-structured interviews were conducted with 22 members of staff in total, spanning from top managers, middle level managers, to operative staff working in the implementation of the programme for sustainability. To qualify as research participant, the member of staff would have been involved in the design or in the implementation of the programme for sustainability. Staff whose daily activities were impacted by the programme for sustainability were also welcomed as participants.

The interview script was divided into four sections, covering: 1) the design of the strategies for sustainability; 2) implementation of strategies, the skills, knowledge and capabilities required to do so; 3) the process of monitoring and evaluating the results of the strategy, the development of derived competitive advantages, potential benefits and/or negative effects; 4) a review of the DCs identified in the literature to confirm their presence.

Data from interviews was complemented with secondary documents and site observations. The interviews were analysed using thematic analysis (Gioia et al., 2013). Firstly, a within-case analysis was conducted for each company, followed by a cross-case analysis to identify patterns and differences across companies.

Findings:

The findings revealed seven DCs present in the case companies when implementing their programmes for sustainability, although with varying levels of strength: Collaboration, Knowledge-related and absorptive capacity, Social Network Relationships, Internal reconstruction, R&D and Innovation, Market-oriented perception, and Cross-functional integration. The analysis also identified the routines constituting each of these DCs.

Additionally, the findings exposed three groups of benefits obtained by case companies as a result of deploying their capabilities during the implementation of their programme for sustainability: benefits supporting the strategies for sustainability, benefits supporting the overall firm function, and benefits regarded as contributing to both areas (see Fig.1).

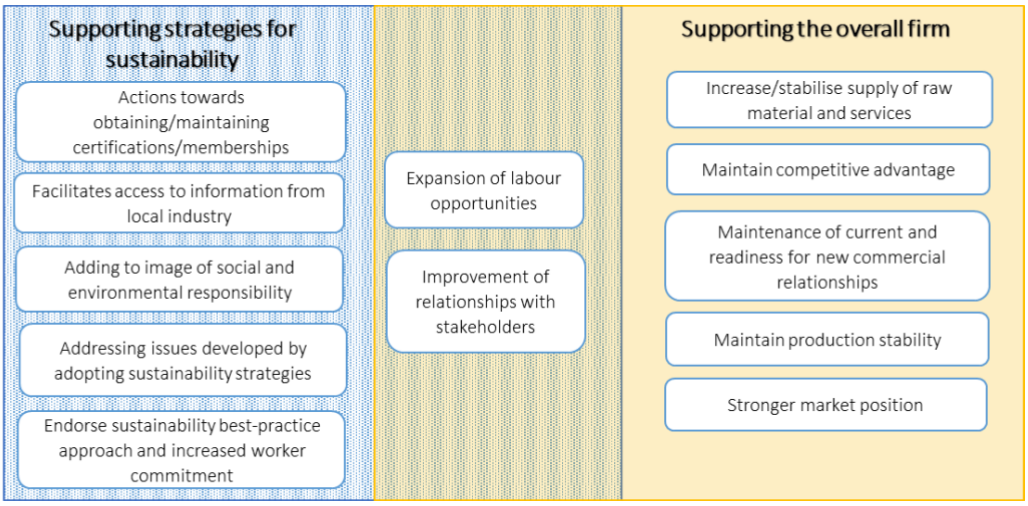

Fig. 1. Specific benefits of DCs for companies implementing programmes for sustainability.

Findings also led to this paper's major proposition: DCs are the mechanism through which firms develop and improve their capacity to face the challenges posed by their context during the implementation of their programmes for sustainability. In other words, DCs support firms in navigating the issues associated to the adoption and implementation of their programmes for sustainability, helping them to realize the benefits derived from these programmes.

Value:

This investigation contributes with empirical insights to the theory of DCs from the context of sustainability. It also provides insights from the setting of emerging economies as suggested by scholars (Amui et al., 2017; Bezerra et al., 2020), and takes a step further by being one of the first studies specifically paying attention to second-tier regions.

The research provides a more comprehensive and empirically supported list of DCs, along with their constituent routines, that have assisted organisations in implementing their programmes for sustainability. This list addresses previous critiques to DCs such as vagueness (Sunder M & Ganesh, 2020), as well as inconsistencies in micro-foundations and routines.

Additionally, this research broadens knowledge on the potential benefits that firms can reap from deploying DCs. There are limited studies on the tangible benefits that companies can achieve by leveraging DCs during the implementation of their programmes for sustainability, and most of them focus on benefits such as maintaining competitive advantages, Triple Bottom Line performance, or identify tautological benefits. This study identifies benefits that have been previously noted individually in the literature but that have not been recognized in the context of implementing sustainability. Furthermore, the study shows that DCs deployed for sustainability purposes can contribute to overall organisational performance beyond supporting sustainability strategies.

The final contribution of this paper is the acknowledgement of DCs as the mechanism through which firms navigate the issues and challenges associated to the implementation of their programmes for sustainability, helping them to realize the benefits derived from these programmes.

Research limitations/implications:

Although the selected number of case studies (five) in the present research is justified, it is insufficient for generalisability of the results due to the descriptive nature of the study. Therefore, further validation of the list of DCs identified in this research will be necessary through the accumulation of new case studies or quantitative testing. This study acknowledges the differences between regions and emerging economies, and thus, the list of DCs and their benefits should be validated in other emerging economies and second and first-tier regions.

Given the research interest in understanding the changes and benefits that occurred in case companies when implementing their sustainability programmes, a longitudinal case study would have been beneficial.

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An Optimization Model and its Solution Algorithm for Scheduling Express Delivery Services Using E-scooters

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Purpose of this paper:

In response to B2C and C2C business models, courier service providers adopt scooters for express delivery service in metropolitan areas, which increases convenience and timeliness for delivery. Besides, along with the growth of environmental awareness, the government actively promote low-carbon transport, which make courier service providers gradually replace petroleum motorcycles with electric scooters to achieve green logistics. However, courier services providers will need to consider vehicle mileage range and the location of charging stations when planning the routing of a fleet of e-scooters. Therefore, the study addresses the optimization problem of scheduling a fleet of e-scooters that are assigned for paired pickup and delivery services.

Design/methodology/approach:

The study proposes an optimization model which is developed based on the time-space network. The objective is to minimize service providers' total operating cost subject to a set of operating constraints for e-scooters. The model is formulated as an integer multiple-commodity network flow problem, which is characterized as NP-hard. Hence, the study develops a decomposition-based heuristic, with the assistance of the mathematical problem solver, Gurobi, to efficiently solve the problem with practical sizes.

Findings :

Teat instances are generated based on the data provided by a Taiwan courier service provider, in order to evaluate the efficiency and effectiveness of the proposed model and the heuristic algorithm. The result shows that the heuristic algorithm takes within 3 minutes to complete the solution process. In addition, the gaps between heuristic solutions and lower bounds that are obtained by Gurobi are less than 8%.

Value:

The proposed model and heuristic algorithm can be used an effective planning tool for scheduling a fleet of e-scooters that are appointed for paired pickup and delivery services.

Keywords:

Express delivery, electric scooters, time-space network, vehicle scheduling problem, heuristic algorithm

Survey on Consumer Choice for Pickup Options Alternatives to Face-to-face Delivery

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Purpose of this paper:

In response to the development of online shopping in Japan, delivery service providers are facing a serious shortage of delivery workers. In addition, many online shopping deliveries in Japan have been based on the service level of major parcel delivery service providers. These major parcel delivery service providers base their services on face-to-face delivery and free re-delivery (no limit on the number of times). Not only delivery service providers but also the Japanese government is trying to reduce labor workload of delivery workers and environmental impact by reducing wasteful deliveries.

This study investigates the extent to which these online shopping consumers in Japan have utilized alternative pick-up options to face-to-face deliveries, and the reasons why they do so. It also discusses the factors that encourage or prevent the effectiveness of each pick-up option and policy.

Design/methodology/approach:

Firstly, we survey current situation of last mile delivery for e-commerce in Japan. In addition, we then conducted two online surveys in 2019 and 2021 regarding the actual choice of pickup options for online shopping deliveries.

In the 2019 survey, we confirmed whether discounted delivery fees would change respondents' willingness to utilize parcel lockers in public space for the delivery of clothing, in addition to whether or not they have utilized each alternative option to face-to-face delivery.

In the 2021 survey, we confirmed whether respondents had experience utilizing a pick-up option, and the reasons why they utilized or did not want to utilize each pick-up option in the COVID-19 pandemic.

In addition to these surveys, we also referred to surveys conducted by various research firms and government agencies to discuss the actual usage of Japanese consumers in online shopping delivery.

Findings:

According to the 2019 survey, more than 70% of respondents said they would not utilize a delivery locker even if it offered a discount on delivery fee. However, the percentage of respondents who said they would utilize a parcel locker or convenience store pick-up service if there was a discount on delivery fee was also higher among those who had used either service at least once. This suggests that the experience of utilizing each of these alternatives to face-to-face delivery may have a positive impact on the willingness to utilize a parcel locker.

The number of respondents who have used convenience store pick-up rose from 23.0% in the 2019 survey to 30.3% in the 2021 survey. Parcel lockers in a public space also accounted for 5.9% of respondents in the 2019 survey, rising to 16.7% in the 2021 survey. The number of "PUDO" developed by Packcity Japan, the largest provider of open-type parcel lockers that can be used by parcel delivery service providers other than specific parcel delivery service providers in Japan, was over 5,100 units at the time of the 2019 survey and 5,700 units in 2021, with most of these units being out of scope. The use of the "front porch delivery" option was not included in the 2019 survey, as it was

only being introduced experimentally by a few operators in Japan at the time of the 2019 survey. Therefore, although comparisons with the 2019 survey cannot be made, the usage rate in the 2021 survey was 44.9%, which is higher than the rate for other delivery options.

Although some respondents utilized delivery lockers in a public space or front porch delivery option to prevent infection from the Covid-19, many chose reasons such as the convenience of being able to pick up their packages at any time, as they do in normal times. In addition, the percentage of respondents who had used convenience store delivery increased. Therefore, it was suggested possibility that prevention of infection with the Covid-19 may not the reason for the change in choosing pick-up options.

Value/Originality:

The major contribution of this study is the identification of changes in consumer choice of pick-up options over time. We also suggested that consumers' previous experience with and attributes of pick-up options may influence their choice of delivery option, rather than economic benefits (discounted delivery fees).

Factors Affecting Job Satisfaction of B to C Delivery Truck Drivers in Japan

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Purpose of this paper:

With the rapid growth of online shopping the demand for parcel delivery is rapidly increasing, thus the shortage of delivery drivers is becoming more and more serious. B to C (Business to Consumer) delivery drivers have different working conditions than B to B (Business to Business) cargo drivers, and there are also differences in job satisfaction and factors that motivate them to continue working.

Regarding B to B drivers, Schulz et al. (2014) pointed out that psychological capital of truckload drivers had a negative influence on truck drivers' intention to quit their jobs. Prokl et. al. (2017) explored the factors of truckload drivers' job satisfaction and identified the influence of financial and non-financial job properties on the job satisfaction and the proneness to retaining the jobs. Oso and Sakurai (2021) studied the effects of drivers' perceptions of human resource management practices, work life balance and health on affective commitment.

Focusing on the B to C delivery drivers in Japan that consist of company employees and independent owner drivers, we aim to clarify the actual working conditions (working hours, delivery methods, salary/remuneration type, etc.), overall job satisfaction, intention to continue working as a driver, and non-financial properties (partial satisfaction, affective commitment, etc.). We also aim to explore the influence of their working conditions and non-financial properties on the job satisfaction and intention to continue working as a driver.

Design/methodology/approach:

Referring existing literature, we conducted a questionnaire on working conditions, overall satisfaction, intention to continue working as a driver, and partial satisfaction with various factors that may affect overall satisfaction and continuity. The questionnaire survey consists of a screening survey and a main survey. Through the screening survey, we selected 681 B to C delivery drivers from the monitors of Freeasy, a survey company, working in transport industry.

Out of the 681 samples, 253 drivers are independent owner drivers who contract with online sellers such as amazon flex, parcel delivery companies such as Yamato's Eazy, or delivery companies such as amazon delivery service partners (ADPs).

263 drivers are employees who belong to parcel delivery companies such as Yamato Transport, Japan Post, and Sagawa Express. 165 drivers are employees who belong to delivery service providers (DSPs) such as Maruwa Unyu Kikan and Ensyu Truck.

We conducted a simple aggregation and cross-tabulation by employment type to clarify the differences between independent drivers and employee drivers.

Based on the existing literature, we develop a conceptual model that not only financial factors, but also non-financial factors impact on overall job satisfaction, and then job satisfaction affect intention to continue working. We test the conceptual model by multiple linear regressions analysis using a questionnaire data.

Findings:

The survey found that independent drivers work significantly longer hours under a pay system according to the amount of delivery than drivers employed by parcel companies or DSPs. Despite of long working hours, the average income of independent drivers is lower than one of employee drivers. As self-employed workers tend to drive their own trucks, they must pay for the cost of purchasing and operating trucks.

Although financial factors of both employment categories differ, there were no significant differences in overall satisfaction and intention to continue working at the current workplace between the categories. Generally, drivers of both categories had low satisfaction with pay and remuneration, but high satisfaction with good relationships among co-workers, and the sense of fulfilment and pride they derive from their work, which suggests the importance of creating good interpersonal relationships and a rewarding workplace.

Although many drivers expect their own working hours to be reduced due to stricter working hour regulations, there is still a strong desire to increase their working hours and increase their income. If working hour regulations are tightened and incomes decrease, many people may want to change jobs from driving. In particular, such intentions are strongly expressed among independent drivers, and there is a high possibility that working hour regulations will have an impact on them.

The sustainability of last-mile networks poses major challenges, especially for independent drivers. In addition to reviewing the wage and remuneration system, raising wages and remuneration, and complying with labor regulations, it is necessary to improve communication in the workplace and create job satisfaction and pride.

Value:

This paper clarified the actual working conditions, job satisfaction, intention to continue working, and factors to impact on them of B to C delivery drivers by employment type. It also focusses on the independent drivers, which are increasingly important in last-mile networks but for which there is little prior research.

In Japan, regulation for light delivery trucks is not stringent, and the working conditions of these drivers are not strictly monitored. As the number of traffic accidents by delivery trucks increases, appropriate regulation on delivery trucks is becoming important.

Therefore, this paper contributes to the understanding of the sustainable development of last mile-mile networks for concerned researchers, governments, and industry.

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The adoption of longer customer lead time in last-mile delivery: benefits, barriers and contingent factors

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Purpose of this paper:

Retailers have been striving to deliver online orders to end-customers as quickly as possible. However the arguments on the efficiency and sustainability of fast and superfast delivery have never ceased and have gained more attention in recent years (Pahwa and Jaller 2023). Various measures have been proposed to improve this problem and one potential method is slowing down delivery speed when possible (Oyama et al. 2024). A few studies have shown that, with longer customer lead time (LCLT), retailers can save delivery cost and improve overall sustainability, for example by enabling better order consolidation (Muñoz-Villamizar et al. 2021).

Apart from this, we have very recently observed live examples of industry offering LCLT options, such as Amazon, who gives customers a 6% discount off their order prices if they were willing to wait 1-day longer than the normal delivery time (Bouma 2023). However, the adoption of LCLT by retailers and the conditions under which LCLT is best suited remains largely overlooked.

Through this paper, we aim to investigate the feasibility of LCLT adoption in the online retail industry to identify when and how LCLT is a viable option. Specifically, we aim to answer 2 research questions: 1) What are the benefits and barriers for the online retail industry in adopting the LCLT? 2) Under what conditions could the LCLT benefit or detract from the online retail industry? By examining these two RQs we are also investigating the challenges of fast delivery for the online retail industry as well as whether the adoption of LCLT could offset some of these challenges.

Methodology:

Given that LCLT is not well-explored in previous literature, and we lack evidence to examine any hypotheses, this study is exploratory in nature. We employ the Gioia method as one of the most useful methods to examine exploratory topics. The Gioia method is based on grounded theory but involves 5 rigorous steps of deriving data structure from participants' perspectives and developing concepts from this process (Gioia, Corley, and Hamilton 2013). The Gioia method is gaining more acknowledgement and is widely used in supply chain management in recent years (Quarshie and Leuschner 2020). We followed the steps of the Gioia method and suggested propositions for the adoption of LCLT in the end.

We collected empirical data by interviewing 22 experts and practitioners in logistics, warehouse, procurement, forecasting and policy-making within the online retail industry in the UK. The selection of these participants was based on their expertise and roles relevant to the exploration of LCLT. Employing the Gioia method, we derived 36 first-order codes, which were subsequently grouped into 10 second-order codes. Finally, we categorized the second-order codes into 3 aggregated dimensions. The data structure formed through this coding process addresses the first research question, and the response to the second research question is encapsulated in the most frequently quoted codes.

Findings:

We found that applying LCLT could bring benefits in terms of improving operational efficiency and sustainability, reducing delivery costs, and mitigating outsourcing risks. Particularly, we observe significant benefits in consolidating customers' orders by slowing down the delivery speed.

Regarding barriers to using LCLT, we identified that most challenges stem from external pressures retailers face in the market. We categorized them into fierce competition in the industry (mimetic pressure), rising delivery expectations from customers (normative pressure) and the need to maintain or improve competitive advantage through fast delivery (instrumental pressure), which is in accord with institutional theory.

While retailers can realize the benefits of LCLT, we sense a reluctance to change and a desire to keep pace with competitors. Just as some participants emphasized, there is a call for policies or regulations that shift attention towards both efficient and sustainable delivery methods. These regulations can be seen as coercive pressure to curb the overly usage of fast delivery. There is also an expectation on retailers/logistics providers to educate customers to choose more sustainable delivery option.

Lastly, we found 13 contingent factors that affect the usage of LCLT, and we grouped them into 3 categories: supply chain network, product characteristics, and customer characteristics. Among all the contingent factors, we identified 4 that participants mentioned most frequently: the level of technology availability, the degree of customer engagement in sustainability, the proximity of the supply chain network to customers and the ease of portability and storability of product. We elucidated these factors in a typology framework illustrating the conditions that best fit the use of LCLT.

Value:

In this paper, we rigorously show the benefit of LCLT, especially in consolidating orders. This finding aligns with the future plan outlined by Department for Transport (DfT) in the 'Decarbonizing Transport' report, where the DfT repeatedly emphasizes the necessity to establish levels of consolidation centers. Secondly, we show the pressures that deter retailers from adopting LCLT. Furthermore, the paper underscores the urgency to implement policies to encourage the use of LCLT and enhance end-customers' understanding of their delivery ordering behaviour. Based on the most important factors influencing the usage of LCLT, we propose the conditions under which retailers can best utilize this approach.

Research limitations/implications:

It would be advantageous to complement the research with other methods to enrich the overall study. For example, future research could incorporate in-depth case studies or empirical research to specifically examine the feasibility of LCLT, delving deeper into how a particular retailer implements slower delivery. Additionally, while we focused our study on the online retail industry, future studies could further explore the impact of LCLT on other stakeholders, including end-customers or suppliers.

Practical implications:

For retailers or logistics providers, this study provides a complementary delivery option to fulfil the existing delivery options by highlighting the benefits and barriers of LCLT. The developed typology framework provides them a guideline to follow as when and how to adopt Additionally, they need to inform end-customers about the benefits of LCLT and implement it as needed. For policymakers, gaining a deeper understanding of LCLT is crucial, and they should consider enacting legislation to guide and support its implementation.

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A Study on the Consumer Perception of Overpackaging in E-commerce Using Topic Modelling Analysis

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Purpose of this paper:

The impact of packaging on the environment and supply chain (SC) is undeniable. With the shift in purchasing patterns to online platforms, the problem of overpackaging in e-commerce (OIE) is increasingly having a negative effect on the environment, notably in packaging waste treatment. However, OIE also significantly affects the entire SC, from packaging production to design, logistics flow, and recycling. Consumers, as the core link downstream of the SC, play a pivotal role in addressing OIE. Understanding consumer willingness to purchase overpackaged products and their perceptions and behaviors regarding OIE is crucial. Despite its importance, research on overpackaging and its impact on consumer purchasing decisions is still in its infancy with limited theoretical foundations. This study aims to quantitatively and empirically track consumer perceptions, issues, and events related to OIE using social media analysis (SMA), providing insights into consumer behavior and potential solutions to OIE.

Design/ Methodology/Approach:

This study aims to identify the honest consumer thoughts on OIE. For this purpose, we collected 9 years of data from 2014 to 2022 from Korean YouTube and conducted frequency analysis and topic modeling analysis in three-year increments based on 2020, the year of the pandemic outbreak when consumption patterns shifted dramatically toward online shopping. Video and comment data were extracted separately. We assumed video as data containing the thoughts of consumers and opinion leaders and comments as data showing consumers' explicit opinions and implicit knowledge of videos. We compared the results to see the difference between the two. To identify important keywords, frequency analysis widely used for information retrieval was conducted. LDA topic modeling analysis was performed to understand the structure of consumer perceptions, categorize and summarize them by topic, and track their time-series trends. Moreover, we conducted an analysis comparing indicators such as the number of likes, ripples, and views to enhance the validity of analysis results and provide rich information. To examine topics that will attract future attention and that will move away from interest, hot topics and cold topics were extracted through regression analysis. This methodological approach not only captures a broad range of consumer emotions but also provides a detailed temporal perspective on changing consumer perceptions.

Findings:

Firstly, we identified that consumers' perceptions of OIE can be summarized into two broad categories: consumption-related issues and environmental ones. The results by period show the trends in consumer thoughts and their changes over time. In the 1st period, consumers expressed complaints about excessive packaging compared to the quantity and quality of products. In the 2nd period, consumers' interest in the negative environmental impact of OIE was revealed. In the 3rd period, post-COVID, we can see that consumers are concerned about the environment, but consumption-related issues such as cost-effectiveness and delivery quality have also emerged, shaping two major themes: environment and consumption. Secondly, the topics to which consumers react sensitively were extracted. While the topic 'Trash Recycling' is a major issue, through the topic 'field labour', we can track consumer perceptions connecting OIE with delivery labour. Consumers' sensitive reactions to government environmental policies show that these policies have significant impacts on consumers' green consumption and perceptions. The fact that eco-friendly packaging-related topics such as 'fresh food packaging development'

and 'eco-friendly packaging' appeared as topics in the videos but were not extracted as comment topics show that, until now, consumers' interest in this part is relatively low, with the exception of recycling. Lastly, the findings show that consumers are demanding a positive redesign of parcel delivery packaging that can satisfy visual satisfaction, protection function, and enjoyable consumption experience. The appearance of keywords like 'design' and 'unboxing' as main keywords, along with the high proportion of topics like 'delivery quality', 'consumer damage', and 'gift packaging', confirm this demand.

Value:

In this study, we sought to understand consumer perceptions of OIE from a different perspective by using SMA. This methodology has not been used in previous studies of consumer value for overpackaging, making it more intuitive and enabling us to understand a wide range of consumers' emotions not seen in them. By collecting data for nine years, a longer period than other SMA studies, we were able to identify changes in consumer perception and response over time. Through attempts to compare consumers' perceptions using various YouTube indicators, we could grasp consumers' reactions to YouTube content from a different view. The novelty of this approach lies in its ability to provide a detailed and dynamic view of consumer attitudes toward OIE.

Research Limitations/ Implication:

Future studies should expand the data source to multiple countries and social media platforms to enhance data richness and validity. The identification of changes in consumer perceptions of OIE, the analysis's full coverage of events and issues, and the discovery of new variables like 'field labour' suggest that SMA is a useful research tool for understanding consumer values and reactions to events.

Practical Implication:

The findings can guide companies and governments in making informed decisions to improve packaging practices in e-commerce. Moreover, the study's insights can significantly contribute to the logistics research community by providing empirical data on consumer-driven demands for packaging improvements, thus aligning logistics operations with consumer expectations and environmental sustainability goals.

Keywords: overpackaging in e-commerce, consumer perception, social media analysis

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Dynamic capabilities in textile recycling supply chain management

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Purpose of this paper:

There is a growing demand for scaling textile recycling to reduce the textile industry's environmental footprint, conserve virgin resources, and contribute to the circular economy (Wójcik-Karpacz et al., 2023). Textile recycling primarily involves mechanical, chemical, or thermal processing of waste materials, with mechanical recycling evolving as a more commercially established and technologically matured process (Duhoux et al., 2021). Additionally, mechanical recycling provides an efficient and economical method to recycle less identical materials as opposed to chemical recycling. However, textile recycling supply chains in general present formidable challenges due to the intricate nature of textile materials, technology barriers, and complexities in reverse logistics management (Dissanayake and Weerasinghe, 2021). Additionally, textile recyclers encounter challenges within their supply chains to survive and succeed in the emerging landscape of the circular economy and uncertain market demand (McCauley and Jestratijevic, 2023). Dynamic capabilities of the focal firm can stand out as critical success factors in overcoming challenges and managing effective circular supply chains(Meier et al., 2023). While scholars have emphasized the importance of dynamic capabilities in circular supply chain management (Khan et al., 2021), the role of dynamic capabilities specifically within the textile recycling supply chains remains unexplored. This study aims to address the gap, given the critical importance of understanding essential capabilities for effectively functioning textile recycling supply chains.

Design/methodology/approach:

This study employs a single-case study approach, focusing on a pioneering leader in Europe's textile recycling sector. The chosen firm is notable for its fully scaled mechanical textile recycling process and vertically integrated supply chain, making it an empirically rich case that covers the entire supply chain operations. Mechanical recycling supply chain is chosen to explore capabilities because it is a more established and matured process, compared with other recycling technologies, which allows for a more comprehensive analysis of capabilities in the textile recycling supply chain. The dynamic capability view (Teece, 2007) and the supply network reconfiguration (Srai and Gregory, 2008) were chosen as the theoretical lenses to explore the microfoundations of sensing, seizing, and reconfiguring capabilities across product, process, supply chain, and relationship categories in textile recycling. Semi-structured interviews served as the primary method of data collection, with five interviews conducted with key personnel involved in business, operations, and logistics. Supplementary data were acquired through field visits, reviewing webpages, and published documents. Interviews were recorded, transcribed, and later subjected to a thematic analysis. Data were coded based on *a priori* coding of sensing, seizing, and reconfiguring to explore the dynamic capabilities essential in textile recycling, and further categorized at product, process, supply chain, and relationship levels.

Findings:

Preliminary analysis indicates that sensing capabilities within textile recycling primarily evolve at the product level by identifying market trends for recycled textiles and emerging demands across various product categories. Building relationships and collaborations with fashion brands and other potential customers are crucial for sensing future market dynamics and emerging demand patterns for recycled products. These identified market requirements lead to sensing internal challenges and opportunities at the product, process, and supply chain levels, particularly in meeting the market demand. Seizing opportunities involves diversifying at the product level and enhancing the quality and flexibility at the process level to efficiently and economically recycle non-homogeneous feedstock to cater to the demand for different product categories. The adaptation of advanced recycling technologies, product diversification, and reconfiguration of a vertically integrated supply chain stand out as critical success factors for achieving long-term operational success and flexibility. This study further emphasizes that the case organization processes strong dynamic capabilities for scaling its recycling process while numerous other players in the textile recycling sector struggle to survive and achieve success. However, the case organization demonstrates a lack of dynamic capabilities in penetrating the market, primarily attributed to the mismatch between anticipated demand and actual customer interest in recycled textiles. Recognizing this obstacle, the firm acknowledges the importance of enhancing its marketing, sales, and communication capabilities to promote recycled textile products and penetrate the market effectively. In essence, effective communication of the value proposition of recycled textiles emerges as the pivotal area for strategic development and growth.

Value:

This study contributes to the limited body of research investigating the dynamic capabilities in textile recycling supply chain management. Traditionally, research in textile recycling has often centred on technical aspects, however, this study breaks new grounds by delving into the strategic management of the supply chain, particularly the dynamic capabilities required to navigate market uncertainties and capitalize on emerging opportunities. The study highlights the importance of sensing market demands and transforming organizational capabilities to align with evolving customer preferences for recycled products. By emphasizing the importance of staying attuned to evolving market dynamics, it provides actionable insights for businesses aiming to navigate the complexities of the textile recycling landscape.

Research limitations/implications:

This study contributes to the theoretical and empirical advances by extending the current understanding of how firms within the textile recycling sector adapt, innovate, and evolve. We illuminate the dynamic nature of their operations and strategies, offering fresh insights into the textile recycling supply chains. However, it is important to note limitations in generalizing findings, as the study sample is restricted to a single case. Therefore, conducting multiple case studies on the same phenomenon would be beneficial.

Practical implications:

Results of this study highlight the significance of practitioners engaged in textile recycling to adapt a strategic approach towards evaluating, enhancing, and transforming their operations in response to evolving market dynamics. By leveraging the four capability categories outlined in this study as a guiding framework, practitioners can conduct a comprehensive assessment of their organizational capabilities, identify potential gaps, and chart a strategic action toward managing a responsive textile recycling supply chain.

Keywords: textile recycling, supply chain, dynamic capabilities, supply network configuration

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Unveiling the role of big data analytics on the relationship between green human practices and logistics social performance

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Purpose of this paper:

By 2050, logistics operations are expected to become the largest contributor to CO2 emissions (Transmetrics, 2022). In addition to harm to the environment, logistics are also negatively affecting people's health in various ways (Kumar, 2022). This concern has fuelled importance of incorporating socially responsible practices in logistics operations, known as Logistics Social Responsibility (LSR) (Carter & Jennings, 2002). However, logistics operations are human-oriented function that rely heavily on green human capital for efficient sustainable logistics performance. Consequently, the promotion of LSR within dynamic environments of logistics operations is linked with effective green human practices to pool employee's capabilities to deal with changing external environment issues (Gruchmann et al., 2019). Despite this obvious need, there is absence of studies connecting the two functions together. In this context, big data analytics (BDA) has become an essential element for deriving valuable insights on how human resources of logistics operations can purposefully change their activities and form new business practices internally and externally to meet sustainable performance requirements (Mahmood et al., 2022). Therefore, this paper aims to explore the role of green human practices on the LSR performance of logistics operations and investigates the moderation effects of big data analytics (BDA) within these relationships. This would explore mechanisms by which GHRM practices can have a positive impact on the social performance of LSPs through the application of BDA. Grounded in the dynamic capabilities' theory, the study posits that human capital can pool their skills to generate new capabilities. Thus, the study posits that logistics' human capital can purposefully form new practices based on extracted insights from BDA to enhance social performance of logistics.

Design/methodology/approach:

This research is deductive quantitative research using a survey strategy. The survey contained four main parts with an additional part to allow for sharing general information on areas covered by research. First section contained five items covering demographic characteristics of participants. Second section contained 29 items covering green human practices adapted from Masri and Jaaron (2017). Third section has 18 items and used to measure LSR and adapted from Miao et al. (2012). Fourth section contained 12 items for measuring BDA practices and were adapted from Mahmood et al. (2022). The 5-point Likert scale was used for measuring each survey item ranging from "strongly disagree" to "strongly agree". To ensure face and content validity of survey, the survey was shared with three academic experts in the logistics area with eight senior managers from logistics industry in the Philippines. Feedback shared confirmed content validity of items included and was mainly on the wording of some sentences. Data were collected from employees with managerial roles (i.e., senior, middle, or lower-level management position) in three largest logistics service providers (LSPs) (anonymised) in the Philippines. In total, the targeted LSPs have 2,363 employees and offer logistics and transportation services in the Philippines and worldwide. Convenience sampling technique was followed to identify potential respondents who are readily and easily available. An online survey link with invitation was sent via email to main contacts in the three LSPs. A period of almost 9 weeks was granted to collect data required. A total of 404 completed responses were received. Data were analysed using the partial least squares-structural equation modeling (PLS-SEM) technique.

Findings:

To ensure model's internal consistency reliability, the alpha Cronbach's coefficients and composite reliability (CR) were greater than 0.70 (Hair et al., 2019), indicating a high degree of internal consistency reliability. To test convergent validity (CV) of the model, Fornell and Larcker (1981) recommended a statistical cutoff of over 0.50 and 0.60 for the average variance extracted (AVE) values and factor loading value, respectively. Our results satisfied these cutoff values. Furthermore, to test Discriminant validity (DV), the Fornell and Larcker's (1981) criterion stipulates that the square root of the AVE must be greater than the value of the inter-construct correlation coefficients. Our results indicated that the square root of the AVE of the constructs was greater than that of the inter-constructs, indicating that there was no issue of DV.

The outcomes of the PLS-SEM testing techniques indicated that green human practices have a positive and direct relationship with LSR (β=0.530, t-statistic=10.665, p-value=0.000). The results of the study also indicated that the potential moderating effect of BDA acceptance on the relationship between green human practices and LSR did not produce statistically significant results (β=0.047, t-statistic=0.958, p-value=0.338). Similarly, the role of BDA adoption as a moderator between green human practices and LSR yielded insignificant results (β=--0.041, t-statistic=0.853, p-value=0.394). However, the results confirmed the significance of the moderating effect of BDA assimilation on the direct relationship between green human practices and LSR (β=0.158, t-statistic=2.418, p-value=0.016).

Value:

Our study introduces dynamic capabilities theory to the nexus between GHRM and SLR for the first time, which reveals previously unknown answers on effects of human capital capabilities on LSR practices. Also, the study determines that BDA assimilation is an important moderator that can strengthen positive impact of green human practices on LSR. Consequently, enriching our understanding of the mechanisms by which LSPs can create their dynamic capabilities to enhance social performance. The study provides a detailed analysis of the antecedents of LSR through investigating the effects of green human practice on LSR. Thus, covering a significant gap in knowledge on what practices foster LSR in the presence of BDA. This warrants to provide a subtle view in literature from the dynamic capabilities' theory perspective on type of green human practices combinations required when faced with logistics operations social ills in the external dynamic environment.

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Three-dimensional concurrent engineering approach towards textile recycling supply network design: mapping key data requirements

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Purpose of this paper:

Recycling as a circular manufacturing option has gained prominence in the textile industry within the scope of circular economy, due to the growing volume of post-consumer textile flow that is unfit for reuse, and to avoid landfill (Hedrich et al., 2022). Globally <13% of post-consumer textiles are being recycled, and current valorisation is hindered by challenges at product-process-supply chain levels. Pivotal to scaling up textile recycling is designing a well-functioning system that can handle the growing volume of textile waste flows (Hinkka et al., 2023), and its logistics, improve feedstock and process quality through standardization and optimization, and align demand and supply in conjunction with end market needs; in other words, design and configure a complex textile recycling supply network optimally.

Crucial to designing such optimal system and configuring its supply network is a three-dimensional concurrent engineering (3DCE) perspective, which presumes that product, process, and supply chain variables should be identified and designed simultaneously, including concurrent development of required capabilities (Ellram et al., 2007). Previous research (e.g. Acerbi et al., 2022), have highlighted the significance of developing and designing data-driven supply networks in context to circular manufacturing, unveiling the need to detect the main categories of data, i.e. product, process, stakeholder management, and technology, and understand how to structure it, to support the underlying decision-making process.

Considering, the essentiality of understanding data categorizes underpinning the supply network design, the purpose of this paper is *to explore and map the specific supply chain, product and process data contingencies and their inter-relations, in context to textile recycling.*

Design/methodology/approach:

A new conceptual data model has been developed taking in account and integrating the extant literature to provide a holistic view on textile recycling from a supply network design perspective.

First step of the model development involved identifying the supply network design aspects. Given the sparse literature on textile recycling practices and the specific characteristics, from a supply chain management perspective, an inductive interview study with semi-structured questions was deemed to be an appropriate and relevant approach. 20 semi-structured interviews were conducted online during spring 2022 with textile recycling supply chain players from Europe, that included collectors, sorters, recyclers, with substantial activities with respect to textile recycling, including a variety of different collection modes, automatic sorting, and chemical recycling.

As an ongoing second step, a data mapping model was established by forming a matrix of the identified supply network design aspects from step 1 and the 3DCE levels (product, process and supply chain). For developing the reference conceptual data model, a literature review was employed to adopt an interpretative approach to detect and categorize different data types, and through an inductive reasoning position them under different categories in the matrix.

Findings:

From the first step of the study via interviews, 11 supply network design aspects evolved. While several of these design aspects were specific to a particular stage in the supply chain (collection, sorting or recycling), such as collaborative collection, efficient sorting operations, or matchmaking recycling and market requirements, other aspects were multi-stage and related to determining geographical scoping and location of different actors, creating traceability and information management systems, and scaled infrastructure and transportation network management.

The second step, based on the extant literature, enabled identification and categorization of different data types at the product, process and supply chain (3DCE) levels. Among the different data categories, the most crucial ones are: (i) number of supply chain tiers and members, and geographical distances in-between; (ii) inventory/stock and material flow at each tier; (iii) process yields and conversion rate based on sorting/recycling technology; (iv) demand volume and feedstock variety and variability in terms of material, colour etc, and (v) costs and prices based on market conditions. Other external data categories relate to textile waste export-import mechanisms, such as taxation and recycling standards.

Value:

This paper defines and develops a conceptual model underpinning a data-driven designing of textile recycling supply network from a 3-DCE perspective. Such a conceptual data model can enable to organize and structure data and information covering the textile recycling business needs, and aid in solving complex decision-making problems inherent to novel supply networks as observed in textile recycling context due to the ongoing reconfiguration/configuration due to the demands of scaling textile circular manufacturing. In circular manufacturing context, some attempts to structure data and integrate different data sources have been done before (e.g. Derigent and Thomas 2016). However by applying the 3DCE perspective to categorize the different types of data required to design 11 different aspects in textile recycling networks we offer a more modular and granular understanding of systems through data models and ontologies, as also highlighted by Negri et al. (2017).

Research limitations/implications:

Our study partly adopts a design science approach, where the research process started with inductive interviews to interpretatively 11 supply network design aspects in textile recycling context, followed by literature review performed to detect and categorize the data types required to design a modular and granular textile recycling system. However, we did not follow-up with the final phase of design science approach, that is validating and refining the model through experts' interviews. Future research is required to perform empirical validation of the data-driven model proposed and use it further for decision-making purpose.

Practical implications:

The conceptual data model developed in this paper can guide the stakeholders (collectors, sorters, recyclers, manufacturers, and retailers) in getting more nuanced understanding of how to design textile recycling supply networks, and what data types are crucial to improve process efficacy and optimize recycling networks and align with market needs. The model offers an ontological framework that can be applied to designing recycling networks in other comparable industrial value chains.

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Towards a Sustainable Future: Exploring supply chain lifecycle management for networked data centres

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Purpose of the paper:

Data centres are the backbones of the increasingly inter-connected supply chains and digital economy. However, in the era of rapid rise of AI and the demand for digitalised products and services, there are direct and secondary repercussions on energy use and energy-related greenhouse gases (GHG), leading to environmental concerns. With the exponential increase in computing needs accompanied by the proliferation of vast data centres and extensive data transmission networks, the demand for electrical energy continue to grow alongside (Shao et al., 2022, Buyya et al., 2024). International Energy Agency attributes about 1.0-1.5% of global electricity use by data centres and associated transmission networks and are responsible for 1% of energy related GHG emissions (IEA, 2023). This figure is much higher, in countries with booming data storage sectors (Buyya et al., 2024). This paper therefore explores supply chain lifecycle management approach to better understand the complexities associated with data centres across its life cycle stages and explore sustainability related strategies. This approach will help us to gain further insights for addressing the environmental, economic, and social impacts associated with products and services throughout their entire lifecycle.

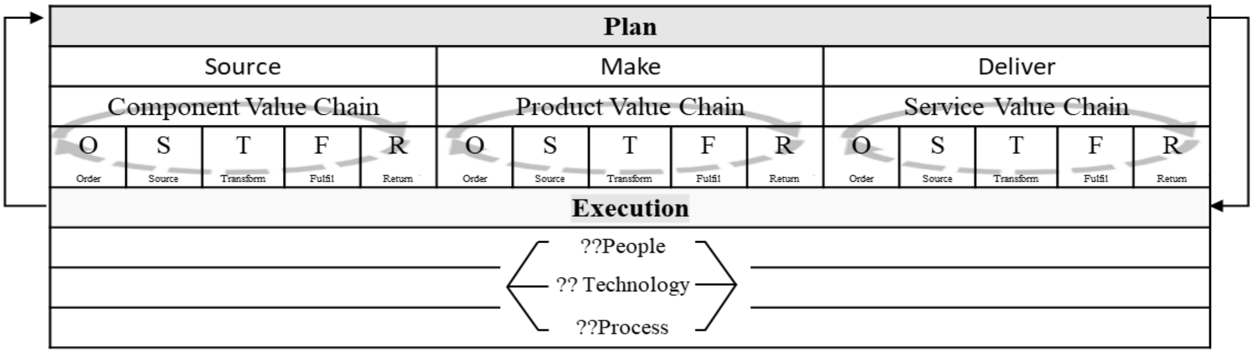
Methodology:

The approach investigates the different dimensions of supply chain management that can be leveraged to support the long-term sustainability goals of data centres. The objective is to identify, analyse, and interpret data to ensure it accurately reflects the realities in relation to the effective management of lifecycle of data centres. The following general research questions are considered as a part of a holistic approach to managing the entire lifecycle of data centers.

1. What are the key dimensions of supply chain management that can be adapted to support the long term sustainability goals of data centres?
2. How can circular economy principles, such as lifecycle management, be effectively implemented in data centers?
3. What critical interventions can minimize the environmental impact of data center operations while maximizing energy efficiency and sustainability?
4. What are the key challenges and opportunities in integrating sustainability principles into data centre dynamics?

Recent research has explored various aspects of data centers, such as their locations, architectures, and social and environmental impacts (Edwards et al., 2024). However, majority of the studies have often confined to sustainability actions within individual value chains, limiting the understanding of interdependencies across supply chains. Additionally, most research has focused on impacts resulting from direct relationships, often overlooking the significance of broader influences and indirect impacts. To address these limitations, a conceptual matrix based on the SCOR model (Digital Standard) was developed as an end-to-end process blueprint (ASCM, 2017). It analyzes data centers across various dimensions, covering the entire lifecycle of a component, product, or service from conception to end use. The framework not only provides a unified structure but also a unique perspective by harnessing people, processes, and technology to drive transformative change in the digital age. This therefore serves as a foundation for

understanding existing knowledge, identifying gaps in the literature, and establishing theoretical and empirical basis for further study.



Findings:

The shift towards whole-life sustainability marks a revolutionary change in sustainability practices by emphasizing long-term considerations. This means estimating embodied, operational, and user carbon throughout their lifecycle, a crucial aspect of carbon calculations following the RICS standard (RICS, 2023). Such a comprehensive approach encompasses component value chains- focussing on tracking the lifecycle of each device used to build a data center such as servers, networking equipment, and cooling systems, the product (data centre) value chain - from design to decommissioning (end-of-life) and the value chain associated with delivering data center services. It's also crucial to adopt circularity principles, such as responsible disposal and recycling for reducing e-waste as data centres are not only generators of e-waste but also consumers of electronic equipment (Hoosain et al., 2023). Hybrid data center strategies, combining public/private clouds with on-premise infrastructure, are pivotal in achieving a balance between computing capabilities and sustainability benefits. Next generation networks promise energy efficiency while addressing the demand for hyperscale, resilient, multi-tier connectivity across computing and storage resources. Location decisions significantly impact functional performance and environmental footprint. The global regulatory landscape prioritizes data privacy, cross-border data transfers, cybersecurity, trade controls, financial regulations, and environmental sustainability. Additionally, data centers must continually adapt to rapid technological advancements, adding further complexity.

These aspects share similarities to strategic supply chain principles that focus on minimizing environmental impact, optimizing resource usage, and promoting responsible practices. Efficient data centre network architectures can therefore be designed leveraging omnichannel closed-loop supply chain designs, optimizing performance in uncertain environments (Niranjan et al., 2019, Yadav et al., 2019). Closed-loop supply chains enhance sustainable performance through inter-organizational relationships under various environmental and socio-economic conditions (Sudusinghe et al., 2022). A lifecycle approach helps navigate complexity in computing tasks, technology evolution, and stringent performance requirements, offering a holistic perspective to sustainability (Patterson et al., 2011). Integrated management of resources and workloads boosts energy efficiency and sustainability (Buyya et al., 2024). Coordinated forward and reverse supply chains create value from products, services, and waste, minimizing negative environmental, social, and economic impacts (Batista et al., 2018, Farooque et al., 2019). An operating model based on real-time demand insights helps identify performance bottlenecks and optimize resources, ensuring optimal performance, reliability, and security. It integrates sustainability across the lifecycle, where the balance of people, process and technology drives action (Fawcett et al., 2007) and help identify opportunities to minimize environmental impact, optimize resource use, and promote social responsibility at every stage.

Value/Originality:

Due consideration of critical factors of data centres during the early-stage design (component value chain), mid-life operations (product value chain), and end-state services (service value chain) will provide further insights into supply chain management complexities associated with data centres. Furthermore, it allows the development of sustainable strategies for data centres to achieve efficiency, optimize operations, improve cost-effectiveness, mitigate risks and enhance overall sustainability of supply chains.

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Exploring Sustainable Coffee Tourism Supply Chain using SDG, Business Model Canvas and SCOR Model

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Purpose of this paper:

In the post-pandemic era, tourists search for a new experience with the new-normal standard, hygiene, and social distancing (International Monetary Fund, 2021). Opportunities and challenges have been dynamic contexts since then. Therefore, this paper explores the role of Sustainable Development Goals (SDG) in managing the tourism supply chain toward sustainability. Since SDG has been initiated in 2015 by the United Nations (UN). UN and member countries have encouraged businesses to employ SDG in business operations throughout the supply chain, such as ESG (Environment, Social, and Governance) initiatives. Since then, most businesses still need help to balance SDG and ESG with their profit target and other business goals (Agrawal et al, 2022). However, some businesses and supply chains succeeded in implementing sustainable practices in their firms and supply chains. This paper explores why and the embedded mechanism that drives a successful SDG-oriented sustainable supply chain. Since the COVID-19 pandemic, tourism supply chains have been significantly affected. New opportunities to create new tourism products arose while the challenges of tourism supply chain management also extended.

Design/methodology/approach:

We designed to explore coffee tourism activities to understand how sustainable tourism supply chains are conducted in the post-pandemic era. Thailand was selected as the case study due to the author's accessibility to exploring various coffee tourism cases. Multiple case study was conducted to compare the different types of coffee tourism in Thailand to sustainable development in terms of an agricultural-based supply chain (Agnusdei & Coluccia, 2022). We selected seven cases of coffee tourism in Chiang Mai and Chiang Rai provinces, where coffee farms are located. Cases were selected based on different factors, including history, activities, and accessibility. Sustainable Development Goals or SDG is used as the research framework to explore how the coffee tourism supply chain fits with SDG and explore the opportunities and challenges. We also employed a value position canvas and a business model canvas to explain the business model of coffee tourism. Supply Chain of the coffee tourism was analysed with the SCOR Model framework.

Findings:

Considering the case study findings, multiple cases show that SDG17 (partnership for the goals) has played a significant role in sustainable tourism supply chain development and collaboration (Chauhan et al, 2022). Governance of the supply chain is significantly related to the key partners and key resources. Key activities stem from the value proposition to enhance the expected gain of the target customers. We also found that exceptional experience developed from the intellectual properties of the supply chain focal firm is vital to the value proposition of the case study that is more sustained. Also, SDG13 (climate action) is highly related to the storytelling of coffee tourism activities since tourists in this segment are conscious customers in the coffee market and would like to support sustainable coffee tourism.

Value:

In this research, we provide insight into sustainable coffee supply chain development using the combined framework of SDG, Value Proposition Canvas, Business model Canvas, and SCOR model. Future research could be examined in the boarder context to raise the generalization of the results found in this research.

Research limitations/implications:

Since we conducted case studies in coffee tourism supply chain in Thailand, results may be limited in terms of generalisation to other contexts.

Practical implications:

We offer practical implications for businesses to apply SDG in their supply chain management toward sustainability and to offer policy recommendations to public sectors that are promoting SDG in practice.

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Impacts of supply chain governance practices on value addition and sustainability in emerging economies: Case of Vietnam's supply chain of aquaculture

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Purpose of this paper:

With its informal and formal mechanisms, governance is used to coordinate and control the behavior of chain partners (Keller et al., 2021; Bonatto et al., 2022). Supply chain government (SCG) is known as supply chain structure design (Tenhiaelae and Salvador, 2014) which ensures smooth information flows and the collaboration/corporation of supply chain stakeholders (Lin et al., 2023). Nowadays, global consumers' preference has shifted into higher value, increasingly processed foods (McCullough et al., 2008) that include additional attributes to price (Adhikari et al., 2012; Collins, 2014). Therefore, to secure the existing markets as well as to join more complex high-value markets, many agrifood cold supply chains' actors in developing countries are attempting to transform their value chains toward sustainability to access higher value markets (Hidayati et al., 2021; Reardon et al., 2019), which means, the supply chain stakeholders have transformed their supply chain structure design and practices to participate in the global market (Gómez & Ricketts, 2013; Tomich et al., 2019).

Since many global agrifood supply chains starting from developing countries were described as "not mature" and still "being transformed" to be more sustainable (Adhikari et al., 2012; Collins, 2014, Hidayati et al., 2021), investigating how supply chain structure design and practices, or in another word "supply chain governance", affect the sustainable value chains when being transformed to serve higher value markets, is attracting the attention of researchers. Therefore, this paper examines Vietnam's supply chain of aquaculture to analyse how SCG practices will affect the value addition and sustainability in emerging economies.

The investigation's outcomes will be used to design a framework of a supply chain governance toward sustainable value addition following the governance models.

Design/methodology/approach:

Vietnam's supply chain of aquaculture is selected as a case study for this research because global aquaculture supply chains originated from Vietnam account for 4-5% total GDP of the country, bring back roughly from 9 to more than 10 billion US$ annually from exporting more than 8.3 million tonnes of products in 2022 (VASEP 2022). From 2019 till now, Vietnam has become the fourth biggest exporter in aquaculture products in the world, only behind China, Norway and Russia (VASEP, 2022).

Following the case study design outlined by Eisenhardt (1989), the applications are selected following criteria: (1) it must be a supply chain of aquaculture, (2) it must contain more than one firm and involve multiple markets, (3) it must be aimed at increasing value addition along the supply chains.

Data is collected under two categories: First is secondary data which was collected from reports, articles, and news, etc. Second is primary data, which includes semi-structured interviews following an interview protocol, which served as an orientation during the interviews regarding both lines of questioning and time. This ensured the coverage of all important topics while leaving room to dive more deeply into specific topics when they arose during the conversation (Eisenhardt 1989). Totally 32 interviews were conducted with key stakeholders of the supply chain plus government officers to clarify all perspectives. This allows the study to complement the primary qualitative insights, providing a more comprehensive view of the impacts of SCG practices on sustainability and value addition. To analyse the data, the NVivo 12 software package was utilised to manage the code nodes and data structures of the study, and to perform data analysis. The themes that arose from the analysis were generalised into a theoretical framework for supply chain governance toward value addition and sustainability.

Findings:

The study has several key findings which are separated from the literature.

Firstly, there are three supply chain governance models in the Vietnam's supply chain of aquaculture in terms of structure design and the collaboration/corporation of supply chain stakeholders in Vietnam's supply chains of aquaculture. They are named as "Traditional/ Transactional model", "Collaborative/ Participative model" and "Corporate governance model". Among these, the "Collaborative/ Participative model" is a transformed model from the "Traditional/ Transactional model ". This finding is like the literature. Upon this transformation, the governance describes market dynamics in arranging and organizing the chain's operational rules. It generally involves vertical and horizontal integration (FAO, 2014; Reardon et al., 2019). However, the third model does not follow the theory of transformation but was settled based on the business leaders' wills.

Secondly, among these models, the final one ("Corporate governance model") shows the greatest power of the key stakeholder (manufacturers/processors) to produce the value addition and to manage the supply chain's sustainability. It also is the model contributing most to the sustainability control and creating the highest value addition for the supply chain.

Finally, the framework proposed by this study not only complements and advances the existing value chains frameworks, but also add a new structure of supply chain governance practices into the literature.

Value:

The study highlights the adversity developing countries' supply chain governance at contribution to value addition and sustainability when service higher value markets. Partially focusing on the transformation mechanism that emphasizes the positive and negative directions, these vectors and orientations require broader investigation, as trade-offs between activities on each dimension are empirically explored.

In addition, the study not only develops the sustainable supply chain governance framework associating with value addition and sustainability which goes beyond previous works in literature, but also drives a distinctive approach to overcoming the major problem in developing countries' transformation. This will contribute to both theory and practice.

Research limitations/implications:

The main limitation is the research is unable to cover all dimensions of value chain transformation but mainly focusing on governance transformation through supply chain structure design and collaborating frameworks. Therefore, the study does not discuss socially engagement activities such as individual wellbeing or increase of employment and engaged with cultural practice, etc.

Theoretically, the enabling mechanism for a supply chain governance being transformed approach are structured regarding three dimensions along with transformation trajectories. A systematic transformation approach allows developing countries' supply chain governances to optimally arrange actions and create effective routes for a higher value addition and toward sustainability practices.

Practical implications:

Practically, the development of a practical guidelines in this study assists both practitioners and policymakers to investigate supply chain's governance transformation and improvement trajectories. The guidelines enable practitioners to assess and self-determine their transformation path to fully align with higher value market requirements.

Correspondingly, the guidelines assist policymakers in terms of delivering efficacious support for the transformation process, by prioritizing and placing their interventions to address specific barriers.

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Understanding Unintended Consequences in Sustainable Supply Chain Management

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Purpose of this paper:

Unintended consequences are, generally, an accepted part of life and are seen as inevitable (Vernon, 1979). Sustainability, as a multifaceted concept, poses unique challenges for supply chain management. While the primary objective of sustainable supply chain management is to minimise adverse environmental and social impacts while maximising economic performance, the pursuit of sustainability goals can give rise to unintended outcomes that may undermine these very objectives. For instance, efforts to reduce carbon emissions through the adoption of green logistics practices may inadvertently increase carbon emissions elsewhere in a supply chain.

Studying the phenomenon has long been an interest of social scientists and economists and complex systems are seen as contributing to the occurrences of unintended consequences. Within supply chain management, the requirement to meet humanity's needs with no further detriment to environmental, social, or economic factors requires an understanding of these complex systems. Whilst supply chain management has studied these complex systems and their interactions giving rise to examples of unintended consequences such as the bullwhip effect (Forrester, 1959), foundational theories of unintended consequences have rarely been applied in the field unlike in related fields (Walsh et al., 2019).

There is a paucity of research into how the phenomenon impacts the sustainability of supply chains, and even fewer studies which apply established theories to the topic (Carter et al., 2020; Matos et al., 2020; Ugarte et al., 2016). By examining the nuances and intricacies inherent in sustainability initiatives within supply chains, this paper sheds light on the potential unintended consequences that may arise, as well as their underlying causes.

In this context, established theories from other fields offer valuable insights that can inform the development of theory in supply chain management. Merton's (1936) theory of unintended consequences, originally formulated in the context of social behaviour, provides a theoretical lens through which to analyse the unintended outcomes of sustainability initiatives within supply chains. In summary, this paper aims to bridge the gap between theories from social sciences and the field of supply chain management by applying the concept of unintended consequences to the context of sustainable supply chains. By exploring the nuances and complexities of sustainability and drawing upon established theories, we seek to advance our understanding of sustainable supply chain management and contribute to the development of theory in this important area of research and practice.

Design/methodology/approach:

The paper applies the theoretical lens of unanticipated consequences to case studies in supply chain management. Merton (1936) categorises unintended consequences as belonging to three distinct types; unexpected benefits, unexpected drawbacks, or perverse results. These unintended consequences are said to be the result of five causes; ignorance, errors in analysis of the problem, immediate interests overriding long-term interests, basic values which may require or prohibit certain actions, or self-defeating prophecies. This paper looks to analyse whether the theory of 'Unanticipated Consequences of Purposive Social Action' holds true for purposive actions in supply chain management, in particular actions taken to improve sustainability.

The theory introduced by Merton (1936) has been applied to other phenomena and disciplines as varied as feminism and technology design (Parvin and Pollock, 2020), performance management systems (Franco-Santos and Otley, 2018), humanitarian intervention (Van der Linden, 2011), European fiscal policy (Nedergaard and Snaith, 2015) and engineering design (Walsh et al., 2019).

The theoretical scope of the paper encompasses Merton's seminal work on unintended consequences and its application in empirical research across different fields. A systematic literature review method will be used, initially, to identify empirical examples of unanticipated outcomes in supply chain management journals. The identified articles will be interpreted as individual case studies (Yin, 2009). Using a deductive content analysis approach, empirical papers are analysed to identify unintended consequences. The analysis focuses on identifying instances where unintended consequences are evident and categorising them according to Merton's typology, as well as identifying which of the five causes can be found.

Findings:

Goel et al. (2019) identify an absence of well-established theoretical frameworks combining sustainability and operations management as an obstacle to theory development. The theory-testing approach taken in this paper applies existing theory to a new context. In the course of this work, instances of unintended consequences are identified and categorised. Unexpected benefits, unexpected drawbacks, and perverse results are found across a wide array of empirical research papers where actions to affect sustainable outcomes have been taken. The analysis highlights the complexity and nuance of unintended consequences, shedding light on their diverse manifestations and underlying causes as elucidated by Merton's theory.

Value:

This paper contributes to theory, introducing established social science theory to the supply chain management context. The supply chain management field recognises the complexities of sustainability and the trade-offs and tensions inherent in managing supply chains, however theory in the area is lacking. As man-made systems, the application of social science theory to supply chain is logical and advances both fields. The paper contributes to the existing literature by providing a systematic framework for categorizing and understanding unintended consequences in empirical research. By applying Merton's (1936) theory, it offers a comprehensive analysis of these phenomena and their implications to sustainable supply chain management. Merton's (1936) theory has previously been applied to secondary data in other fields to develop generalisable theory (Wallace and Hoyle, 2012). The findings of this research hold value for researchers, policymakers, and practitioners seeking to anticipate and mitigate unintended consequences in their respective domains.

Research limitations/implications:

While this paper provides valuable insights into unintended consequences in empirical research, it is not without limitations. Future research could delve deeper into the specific mechanisms through which these consequences arise, as well as explore potential strategies for addressing them. Additionally, the applicability of other established social science theories to the topic warrants further investigation, along with the development of more refined methodologies for analysing unintended consequences in research.

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Shedding Light on Challenges: Analysing Green Public Procurement in a Developing Country

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Purpose of this paper:

Public procurement spending typically accounts for an average of 14.5% of budgets in low-income and developing countries, making it a potentially strategic tool for promoting environmental sustainability (SDG12.7 2024). Green public procurement (GPP) is associated with the procurement of environmentally friendly products and services to ensure that organisations' environmental goals are met (i.e., reducing harmful environmental impacts and recovering value) throughout the life cycle of these products (Appolloni et al. 2014; Ahsan and Rahman 2017). While there is extensive research exists on green public procurement (GPP) systems in developed countries (Ahsan and Rahman 2017; Bakir et al. 2018; Sparrevik et al. 2018; Al Nuaimi et al. 2020; Braulio-Gonzalo and Bovea 2020; Burghardt and Pashkevich 2021; Kristensen et al. 2021; Dimand 2022; Bryngemark et al. 2023), there is a notable lack of studies focusing on sustainable public procurement in developing countries (El Haddadi et al. 2021; Jacob Nsiah-Sarfo et al. 2023; Shaikh et al. 2023). On the other hand, sustainable procurement practices in developing countries could contribute to drive economic development (Maina and Hansen 2023). Given the importance and scarcity of environmental sustainability in public procurement in developing countries, this study aims to explore the challenges associated with implementing sustainable practices in procurement processes in a developing country context. Specifically, our research seeks to identify critical organisational and stakeholder barriers that hinder the effective implementation of GPP initiatives.

Design/methodology/approach:

After conducting an extensive literature review, we construct a framework for GPP implementation, that includes two primary categories of challenge, six subcategories of challenges, and 16 different challenges. The categories of challenges are underpinned by natural-resource based view and stakeholder theory perspective. The combination of these theories has high potential to develop a powerful framework to explain the stakeholder influence and relationships in sustainability such as GPP (Freeman et al. 2021). The problem is structured using an Analytic Hierarchy Process (AHP)-based multi-criteria decision model. The study considered the Bangladesh public sector as a case to investigate GPP in developing countries. In order to prioritise the critical challenges, we conducted interviews with 28 procurement experts with MCIPS qualification from different public sector organisations. These structured interviews, based on AHP, involve discussions with public health procurement executives to gather data and insights.

Findings:

Analysis reveals that the critical implementation challenge categories are predominantly organisational in nature. The major challenges are related to senior management support on GPP, clear strategic goal on environmentally sustainable procurement, understanding on green policy at different level of the organisation. In addition, the need for supplier knowledge on green issues, NGO pressure, working with green suppliers and developing green suppliers are less challenging at this stage. The study concludes that for effective implementation of GPP, public sector organisations need to focus on internal goals and strategies. We also compare the findings with other studies from developing and developed countries.

Originality/Value:

This study contributes to both the procurement and sustainability literature to conceptualise the challenges of fostering green procurement and SDG 12.7 in public sector

organisations, leading to the incorporation of SDG targets through procurement practices. This study also contributes to the development of new knowledge to assist or support the identification of challenges to help government organisations focus on key issues before attempting strategies to work on GPP.

Research Limitations:

This study is conducted from the perspective of one developing country. Therefore, the findings of the study may be applicable or generalisable to other developing countries with similar socio-economic backgrounds, or further research may be needed to apply the findings to other developing countries.

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Building Resilience for Supply Chains

Evaluating Novel Food Supply Chains From a Resilience and Cost Perspective: A Study on the Alternative Protein Industry

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Purpose of this paper:

The purpose of this research is to study the concepts of supply chain (SC) resilience and the associated cost within the context of novel foods. Traditional diets pose a resource-intensive food option, as meat contributes to approximately 20% of greenhouse gas emissions and raises significant health concerns (e.g., antibiotic resistance, cancer). Nowadays, such sustainability concerns have fostered the configuration of novel food SCs. However, as innovative food production technologies and end products emerge, a key question revolves around how the new SCs should be configured. Existing food SCs design is inefficient, complex, and far from resilient (Ali et al., 2021), negatively contributing to the United Nations Sustainable Development Goals (SDGs) (i.e., SDG #2 'Zero Hunger, SDG #12 'Responsible Consumption and Production'; SDG #13 'Climate Action'). Unless reconfigurations are applied, novel foods SCs risk inheriting the traditional problems from typical SC models.

This research focuses on Alternative Proteins (APs) due to their unexploited potential to feed future generations and promote the transition to more sustainable food production systems (GFI, 2022). APs, derived from plants, algae, animal cells, or by way of fermentation, can offer an alternative to meat, which plays a central role in humans' diet but poses sustainability challenges. Since AP is a growing industry expected to claim as much as 22% of the overall protein market by 2035 and reach a value of at least $290 million, they represent an interesting opportunity to study novel foods SCs (BCG, 2021).

However, there are competing and pressing priorities that strengthen the perception from companies that building resilience and sustainability is expensive. Thus, novel food SCs often question their financial capacity to invest in resilience. This work addresses this gap by posing the following question: How do novel food SCs balance cost and resilience to thrive in a competitive, uncertain and disruptive environment?

Design/methodology/approach:

This study adopts a qualitative multiple-case study method, with the unit of analysis being food SCs, to gain an in-depth understanding of the novel food SC configuration. The research specifically focuses on four AP SCs, which: (i) have at least tier 3 suppliers; (ii) are in the "growth stage" of their product lifecycle; and (iii) locate the manufacturing operations in the UK and Europe. The case studies include semi-structured interviews, archival documents, and observational research methods, incorporating both within-case and cross-case analyses (Eisenhardt, 1989). Stakeholders' engagement results are analysed qualitatively through inductive coding and thematic analyses. Specific analysis constituents include: (i) exploring the SC typologies within the AP industry; (ii) identifying crucial value chain activities and vulnerabilities within the SCs; (iii) defining mitigation strategies along with the corresponding activities and resources needed; and (iv) conducting maturity assessments to understand further how novel food SCs measure their level of SCRES in practice and how trade-offs are managed. This analysis aimed to develop (i) a robust supply chain resiliency assessment framework interlinked to alternative food SC typologies; with insights into the industry dynamics along the dimensions of resilience and cost; and (ii) a blueprint of actions to improve resilience.

Findings:

Exploring SC typologies within this context highlights innovative structures that can help balance cost efficiency and resilience. Interestingly, the SCs reveal unique characteristics, including: (i) shorter upstream SC processes; and (ii) the use of specific ingredients for local production. Some growing firms have demonstrated a degree of resilience in practice, particularly those embodying responsive and agile SC typology characteristics. For example, production close to the consumer, standardised components for different product versions, and pooled capacity resources.

Regarding vulnerabilities, constraints in scale and financial resources impact SCRES capabilities like redundancy and flexibility. These SCs also face challenges in collaborating or influencing other stakeholders to enhance capabilities such as visibility or velocity and in dedicating time to prevention measures such as creating a risk-oriented culture. Furthermore, they possess less-developed information-technology systems, specific products for very niche markets, scarcity of suppliers, lack of standardisation on the quality of the sources, absence of ingredient-extraction technologies, high production costs, reliance on local dominant technologies, and taste imitation requirements. Finally, these SCs face external challenges like regulatory barriers, limited influence over SC partners, and regional environmental changes.

Mitigation strategies, such as localised sourcing, supplier diversification, and digitalisation initiatives, effectively address some of these challenges. However, maturity assessments highlight the need for collaborative models within the industrial ecosystem where institutional support and other firms can provide additional capabilities to build resilience. Prioritising collaboration actions can help counteract disturbances, technological limitations and constrained resources.

Value:

Our research contributes to the Supply Chain Management field by addressing a SC challenge with significant socioeconomic and environmental implications. It clearly demystifies the attributes to configure cost-effective and resilient SCs based on the utilised AP, to ensure affordable and continuous access to nutrition, especially in the face of disruptions. We develop a pragmatic view of resilience in novel food SCs and propose a solidified and practical maturity tool to assess the level of SCRES and costs, helping inform the decision-making processes. The tool could guide actors towards pertinent System Dynamics modelling efforts that can catalyse scenario planning and act as a decision-making tool when evaluating SCRES and cost.

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Should Recovery Strategies be Reuse - or Recycling based? A Case Study on Electronics in Melbourne Australia

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Purpose of this paper:

Typically, optimizing reverse chains is more difficult than forward linear supply chains due to increased complexity and uncertainty. Careful consideration should be given to recovery strategies to optimize reuse and recycling. The optimization criteria are three-fold, maximizing profits, maximizing recovery rates and minimizing climate impact.

Methodology:

We applied an ILP based calculation model with four recovery options. It models different return quality levels, three market segments, cost structures, buy back - and resell prices, carbon emissions, and percentage of reuse and recycling for the four Rs (volume based). The Melbourne area collection project supplied part of the required data to analyse, so other published sources from desk based analysis were used to assess the model parameters.

Findings:

Starting with a "base case" data set comprising 450 products we will compare 15 recovery strategies with 1,2,3 or 4 options. Within each strategy we carried out a 'drill down' on specific characteristics and conducted sensitivity analysis (called scenarios) to explore the extremes of the spectrum.

Value:

Analysis indicates; higher specification, relatively new devices, that require no parts repair/replacement, are commanding a higher purchase price making it viable for reuse. Without this combination of characteristics, there is a low probability of reuse and recycling is the only feasible option. The results are summarized in heuristics, i.e. evidence based modelled outcomes that should be robust yet relatively simple to implement.

Limitations:

The case study was conducted in Australia, results may be different in other parts of the world. Other topics for further research include economies of scale effects, market cannibalization between new built products and reused ones, footprint of the user phase, impact of collection rate, life cycle reuse (how long do reused products stay in the market), The removal of information and data during the refurbishment, and pro-active buy back policies

Carbon footprint analysis of reusable containers in cold chain logistics

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Purpose of this paper:

Growing demands from customers for the mitigation of greenhouse gas (GHG) emissions, coupled with an emphasis on social responsibility, serve as significant driving factors for sustainability within cold chain companies. Hence, firms are not only focused on minimising operational expenses but also on measuring and decreasing carbon emissions resulting from logistic operations (Wong et al., 2018)

The aim of this case study is to create a user-friendly carbon footprint software application designed to estimate CO_2 emissions directly associated with the movement of temperature-controlled containers.

The application seeks to equip Tower Cold Chain Solutions, a temperature-controlled container rental company in the pharmaceutical industry, with an effective tool that transparently reports carbon emissions generated during the transportation of products.

Aligning with Tower's vision of sustainability, estimating carbon footprint reflects the company's commitment to minimising its environmental impact, particularly concerning transportation-related emissions. By offering a comprehensive assessment of carbon footprint data, the Carbon Footprint Estimator (CFE) aims to provide actionable insights that empower informed decision-making at various stages.

Design/methodology/approach:

The methodology employed in the development of the CFE is rooted in a systematic approach. The calculation of carbon emissions follows this approach, utilising conversion factors sourced from the UK’s Department for Energy Security & Net Zero (DESNZ) and the Department for Environment, Food & Rural Affairs (DEFRA). These sources provide up-to-date emission factors for all modes of transportation, ensuring the accuracy and reliability of the CFE’s estimations (Greenhouse Gas Reporting: Conversion Factors, 2023).

The CFE application features a comprehensibly designed user interface where users can select the container type and specifics, mode of transport, quantity of containers, distance of the shipment, and load weight.

Built on the Anvil platform, an open-source web development framework, the CFE incorporates a Python notebook model housing a dataset encompassing container weights and temperature specifications. Upon user selections, the application computes total weights and emissions factors based on shipping distances, transportation modes, and cargo vessel or vehicle types relevant to Tower’s operations.

Findings:

Through analysis and iterative refinement, the CFE yields valuable insights into the environmental impact of not only Tower's operations but the supply chain industry as a whole. Stakeholder feedback from within Tower highlight a growing awareness of environmental concerns within the logistics sector, reflecting a broader industry trend toward sustainable practices and responsible supply chain management.

As the deployment of the CFE develops within Tower, sales teams have been able to use the analysis to demonstrate Tower’s environmental credentials and competitive advantage in sustainability-minded markets.

Value:

Despite the availability of many reliable open-source carbon estimators that can be accessed online, the primary value of the CFE lies in its tailor-fit design specifically for Tower's products and customer focused processes. This customization not only enhances the accuracy and relevance of the carbon footprint data but also significantly increases awareness and commitment to sustainability within the company. Moreover, this initiative aligns seamlessly with other sustainability efforts such as EcoVadis assessments and ESG committee activities.

In the broader context, for companies in the logistics sector aiming to be more sustainable and environmentally friendly, providing customers with transparency regarding GHG not only attracts new customers but also helps retain existing ones who share similar sustainability objectives. Thus, the CFE not only supports Tower's internal sustainability goals but also strengthens its market position by aligning with the growing demand for environmental accountability and transparency.

Practical implications:

The practical implications of the CFE extend across various facets of Tower's operations, from strategic decision-making to customer engagement and stakeholder relations. By leveraging the application's estimations, Tower can make more data-driven choices regarding transportation modes, route optimisation, and supply chain management, thereby minimising its carbon footprint while maximising operational efficiency and cost-effectiveness.

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Decentralized and circular food waste-related supply chains: success and failure factors

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Purpose of this paper:

Food loss and waste leads to many problems for humanity, including land and water waste, over use of scarce resources, as well as the generation of greenhouse gases (De Menna, Dietershagen, Loubiere, & Vittuari, 2018). A thriving ecosystem of companies and start-ups are now seeking to mitigate the impact and ultimately even solve food waste (Ciccullo, Fabbri, Abdelkafi, & Pero, 2022). The circular economy and bioeconomy principles help in this endeavor (Carus & Dammer, 2018). However, it is noticeable that some of these companies thrive, whereas others fail (Baldassare & Calabretta, 2023). Circular economy companies have some special features and sometimes even difficulties in their operations in comparison to "regular" companies in a linear supply chain that need to be considered in daily business life. For example, many types of waste are generated in irregular/unpredictable amounts or timeframes, making them difficult to plan. Furthermore this waste may be generated decentrally, at various locations and must be collected using different supply chain systems (specific examples of this will be provided in the paper).

In this exploratory work, the researchers seek to find out what makes companies with decentralized supply concepts in the context of food waste supply chains succeed or fail. Following on from this, are there crucial factors that determine success or failure?

Design/methodology/approach:

Our study is both qualitative and quantitative in nature, driven by the results of primary data (semi-structured interviews and surveys with food waste-related startups and businesses in the countries Germany, Austria, and Switzerland). The interviews are conducted following the structure of the (Sustainable) Business Model Canvas (Cardeal, Höse, Ribeiro, & Götze, 2020).

Findings:

Our study identifies various factors that contribute to the success or failure of decentralized food waste supply chains and proposes a conceptual framework, together with practical implications on how to create new decentralized food-waste related value chains. These insights provide pointers towards aspects of what constitutes innovative practical business models in this field.

Value:

The study aims to contribute to the creation of new, sustainable, and circular supply chains and business models, to foster bioeconomy, to create more resilience and independence within local supply chains and to diminish raw material dependencies, not only, but especially in politically turbulent times.

Research limitations/implications:

Accessibility of failed founders

Practical implications (if applicable):

To be successful in the future, it is always important to learn from the past. The findings of this study can show potential entrepreneurs or existing startups/ companies especially in terms of food waste related circular economy and bioeconomy, what factors they must

focus on creating an economically successful company and to avoid failure. They can learn from the success and failures of other companies.

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The Nexus between Organisational Culture and Competitive Advantage: Does Supply Chain Collaboration Matter?

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Purpose of this paper:

Although supply chain collaboration has received considerable research attention in the last few years, relatively few companies have achieved genuine collaboration with their supply chain partners to obtain the desired performance outcomes due to various influencing factors (Maskey *et al.*, 2020; Tran *et al.*, 2023). Among the explored antecedents of this practice, organisational culture has emerged as a controversial factor, with notable inconsistency persisting in previous studies regarding the relationship between organisational culture and supply chain collaboration (Porter, 2019; Taha *et al.*, 2022). Furthermore, prior research has primarily focused on the direct relationship between organisational culture and firm performance (Pinho *et al.*, 2014), overlooking the potential mediating role of supply chain collaboration in enhancing competitive advantage. This paper aims to address these gaps by investigating the mediating role of supply chain collaboration on the relationship between organisational culture and competitive advantage in the context of garment firms in Vietnam.

Design/methodology/approach:

Underpinned by the Relational View (RV) and Organisational Culture (OC) theories, a conceptual framework on the interrelationships between organisational culture, competitive advantage and supply chain collaboration was proposed and hypotheses were developed. A survey questionnaire was developed and disseminated to potential participants through the Qualtrics platform after the pre-test and pilot test. The research population was garment manufacturers, as they are the main players in the garment supply chain in Vietnam. The unit of analysis of this study was the organisation. Rigorous data examination using SPSS was performed, and this procedure resulted in 192 valid responses retained for further analyses. Factor analysis was performed to assess the internal consistency of the attribute combination in SPSS. Subsequently, the Confirmatory Factor Analysis was employed to evaluate the convergent and discriminant validity of the constructs. The mediation effect of the constructs was assessed using the bootstrapping method (Zhao *et al.*, 2010) to examine the significant indirect effect among 192 cases and 5,000 samples. The first step was to investigate the significance of indirect relationships, that is, the relationships between the independent variable and mediator, and between the mediator and dependent variables. Then, the types of mediation were classified by examining the significance of direct effects on the relationship between independent and dependent variables without the mediator.

Findings:

The results demonstrate that organisational culture had a significant direct effect on cost competitive advantage. Also, supply chain collaboration was shown to fully mediate the relationship between organisational culture and differentiation competitive advantage. However, the mediating role of supply chain collaboration on the relationship between organisational culture and cost competitive advantage was not statistically significant. Similarly, the mediating role of cost competitive advantage on the relationship between supply chain collaboration and differentiation competitive advantage was not statistically significant.

Value:

This study contributes to enhancing the existing body of knowledge in several ways. First, while most previous studies investigated the importance of organisational culture in relation to operational performance, this research also found that organisational culture positively impacts competitive advantage. Besides, this study is perhaps one of the first empirical attempts to examine the mediating role of supply chain collaboration on the relationship between organisational culture and competitive advantage in the garment industry in Vietnam. In fact, far less attention was given to the mediating effect of supply chain collaboration on the operational culture – competitive advantage relationship in the extant literature. This research hence contributes to expanding the existing knowledge on the role of supply chain collaboration by providing an all-rounded understanding of this concept in both the literature and management practice. Moreover, this study extends the application of the RV and OC theories in explaining these relationships in a new research context.

Research limitations/implications:

The data analysed in this study was collected from garment manufacturers - the focal firms in garment supply chain. Therefore, obtaining data from dyadic relationships, namely, their suppliers and customers, could offer more comprehensive insights into how organisational culture effect collaboration and competitive advantage. Additionally, this research investigates the topic only within the context of Vietnam's garment industry. Future research could enhance the finding's reliability and validity by investigating this topic in other settings such as different industries and countries.

Practical implications:

This study found that supply chain collaboration fully mediates the relationship between organisational culture and differentiation competitive advantage. This finding implies that senior management should establish and implement measures to promote development and group culture practices so that their firm's differentiation competitive advantage can be enhanced. The full potential of these practices would be further realised by strengthening various supply chain collaboration activities, such as information sharing within the firm and across supply chain organisations through technological platforms.

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Exaptation capabilities for supply chain resilience: the case of Covid-19

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Purpose of this paper:

So far, the literature has paid little attention to how organization may apply or repurpose newly acquired capabilities when supply chain operations return to a post-disruptive environment. From a theoretical point of view, the repurposing of acquired capabilities during a crisis or disruption can be linked to the concept of exaptation (Dooley and Som, 2018; Gould and Vrba, 1982). A striking example of exaptation in supply chains resilience management during Covid-19 was the ability of the company Dyson, a manufacturer of hand-dryers, vacuum cleaners and air-purifiers, to repurpose their supply chains, manufacturing and product designs to rapidly switch and build urgently needed ventilators for hospital patients (Liu et al., 2021). Studies about the exaptation and its potential are rather limited, in particular regarding supply chain resilience (Herold et al., 2024a). As a response, this article attempts to shed light on how the newly acquired resilience capabilities are utilized or repurposed after a disruptive event. We argue that the exaptation potential of supply chain resilience capabilities depends on both exploitative capabilities, i.e. to what extent companies could exploit their capabilities during the Covid-19 pandemic, as well as exploratory capabilities, i.e. to what extent companies have explored, learned and utilized new skills to transform and repurpose their resources for a long-term resilience after the Covid-19 pandemic. In particular, we try to answer the following research question: "How do exploitative and exploratory supply chain resilience capabilities influence the exaptation potential after Covid-19?"

Design/methodology/approach:

In order to measure the exploitative and exploratory supply chain resilience capabilities and its exaptation potential, we conducted a survey among supply chain senior managers in Australia in June 2023, i.e. what can considered post Covid-19 (WHO, 2023). Following Mandal et al. (2016), the questions focused on specific supply chain resilience capabilities and its practices, namely supply chain resilience, supply chain collaboration, supply chain visibility, supply chain flexibility and supply chain velocity. Questions specifically asked to what extent supply chain resilience capabilities have been a) exploited in the beginning of the Covid-19 pandemic, and b) explored to transform the supply chain for future and long-term resilience. Our sample comprises survey responses from 447 senior managers in Australia from various supply chain industries. Our main theoretical focus is the distinction between exploitative and exploratory resilience capabilities and how the interaction between them influences the exaptation potential of supply chain capabilities. Based on the relative degree of the combined exploitative and exploratory resilience capabilities, we propose four types of exaptation potentials: Impeded, Configurative, Transformative, and Ambidextrous.

Findings:

In contrast to literature that claims that supply chains are confronted with an inherent trade-off between exploitative and exploratory capabilities, we found that the majority of supply chains are able to simultaneously pursue and develop exploitative and exploratory capabilities (Ambulkar et al., 2023; Swierczek, 2024; Herold et al., 2024b). Thus, companies seem to be better prepared for upcoming disruptive events. Interestingly, the numbers show rather homogenous results across the exaptation potential types, i.e. the respective types (Impeded, Configurative, Transformative, and Ambidextrous) show similar results across RMPs and capabilities, indicating that supply chain resilience capabilities are consistently and collectively developed and utilized rather than individually. One of the key findings of this study is that 83 per cent of supply chains show Transformative and Ambidextrous exaptation potential, emphasizing the greater role of exploratory RMPs when building supply chain resilience after Covid-19. In particular, 267 out of 447 supply chains have utilized both exploitative and exploratory capabilities to a greater extent, thus showing Ambidextrous exaptation potential. In other words, these supply chain showed how to exploit existing knowledge and how to build new knowledge to increase the resilience along the supply chain.

Value:

The contribution of this article is threefold: First, we use and integrate the concept of exaptation into the current discourse around supply chain resilience to illustrate how newly acquired capabilities during a crisis are utilized or repurposed after supply chains have returned to the 'new normal'. Second, we use the main concepts of exploitative and exploratory capabilities to build an integrative model that depicts four different types of exaptation potential for supply chain resilience in supply chain organizations, thereby providing conceptual clarity regarding the varied implications and outcomes linked to the exaptation of resilience capabilities in supply chains. Third, we empirically categorise the exaptation potential in and for supply chains, thereby advancing the literature on supply chain resilience and providing a tool to assess how innovation can be captured in an organisation. Thus, this study presents a more nuanced empirical, as well as theoretical, understanding of the mechanisms through which exploitative and exploratory resilience capabilities influence exaptation potential.

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Transforming Supply Chains for Resilience: Leveraging Adaptive Learning and Agility in Turbulent Times

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Purpose of this paper:

As supply chains (SCs) become more globally intertwined, they are more prone to breakdowns and disruptions. SC disruptions like the Red Sea attacks or the COVID-19 pandemic have threatened closely interwoven networks and significantly affected companies' operational and financial performance. A firm's crucial challenge is therefore to become more versatile, adaptable, and robust to cope with the dynamic market demands (Hohenstein, 2022; Klöckner et al., 2023). This paper investigates how the antecedents of organizational learning (OL) and organizational agility (OA) have impacted supply chain resilience (SCR)

amidst the competitive challenges in times of crisis during the COVID-19 pandemic.

Numerous scholars have urged for more research to pinpoint the SC challenges that emerged uniquely during th. This call aims to identify lessons from experience, enabling better preparation for sudden SC disruptions that might occur in the future. Thus, OL in SCM from past experience can bolster SC professionals' skills and knowledge, allowing firms to adapt and reconfigure their SCR practices to better respond to sudden SC disruption in the future (Acar et al., 2023). Likewise, an integral part of organizational agility (OA) is SC agility, allowing partners along the SC to respond swiftly and effectively to dynamic market fluctuations and uncertainties, thereby establishing a competitive advantage (Braunscheidel & Suresh, 2009; Gligor et al., 2020). We seek to answer the following research questions:

RQ1: How has organizational learning influenced a firm's supply chain resilience in crisis conditions?

RQ2: How has organizational agility improved a firm's supply chain resilience capability in crisis conditions?

Design/methodology/approach:

The COVID-19 crisis has created many opportunities for meaningful and practical research on SCR from a holistic process perspective. According to Yin (2018, p. 15), the case-study format is well suited to investigating "a contemporary phenomenon (the 'case') in depth and within its real-world context," particularly when "the boundaries between phenomenon and context may not be clearly evident." We draw on the resource-based view and combine a literature review with a rigorous multiple-case study design. Based on fifteen interviews with seven firms operating globally in different industries, our paper examines how these case companies used OL and OA to strengthen SCR in response to the COVID-19 pandemic.

Our multiple case-study approach follows the recommendation of Eisenhardt (1989), emphasizing that four to ten cases appear to be adequate for a multiple case-study design. The case sample comprises companies headquartered in Europe to ensure that all share similar infrastructural, legal, and political environments. However, to represent a range of perspectives, we deliberately selected firms of various sizes and with a range of industry focuses and practices to deal with sudden shocks. All of the selected firms—from manufacturers and retailers of consumer goods to healthcare, electronics, and logistics service providers—operate in global SCs and were strongly affected by the COVID-19 pandemic

Findings:

Our findings provide empirical evidence that OL and OA as a strategic, intangible resource have a strong positive influence on an organization's SCR, thereby enhancing competitiveness in times of crisis. Our study highlights that OL (e.g., through learning programs, employee engagement) has a direct impact on SCR by facilitating more robust response to SC disruptions, while OA (e.g., through communication, collaboration, digital transformation) enhances firms' capacity to respond to disruptions more swiftly.

More specifically, our interview data revealed that organizations need to inject a DNA of willingness to foster OL by changing, adapting, and reconfiguring in response to extreme turbulence in dynamic environments. Our case informants emphasized the clear need to learn how to cope with exceptional disruptions in the future, and therefore to consider the change caused by the pandemic as an opportunity to further shape an OL culture.

Furthermore, data from our interviews revealed a clear need for improvement in cooperation among SC network partners to handle the disruption the COVID-19 pandemic caused. Several informants reported that a narrower focus on improving relationships among multiple SC members helped them maintain the flow of goods and materials. Moreover, knowledge-sharing among key SC partners was essential in keeping all parties informed of the current status of the disruption. Although some firms were reluctant to share information, most firms found that collaborations intensified and became more open during the pandemic, which helped all partners react more effectively.

Value:

Our study extends the understanding of SCR practices by exploring the effects of OL and OA on SCR reconfiguration in a post-pandemic world. Our study draws on the RBV and contributes to the literature by offering a novel viewpoint. Thereby, we integrate OL and OA into a unified SCR theoretical framework, specifically in the context of the COVID-19 pandemic. From a managerial perspective, the value of our research is empirical-based recommendations. For instance, leaders and managers should foster a culture of OL and OA with forward-looking perspectives to engage SC employees. Exchanging expertise and sharing experience and best-practice approaches from the COVID-19 pandemic must be turned into proactive action, for example by establishing cross-functional employee risk management training programs and creative working environments that stimulate unconventional thinking to find new ways of handling disruption.

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Learning Governance from Indigenous Supply Chains

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Purpose of this paper:

There is continuing interest in how organisations develop supply chain governance to deliver value (Shamsollahi et al, 2021). Some authors have focused on governance in terms of supply chain structure and management approaches (Brito et al, 2017). Others have explored the question of how to balance contractual and relational approaches (Bai et al., 2016). Yet, others have considered the merits of different theoretical lenses, including transaction costs economics, resource dependence theory, network theory and principal agent theory, to comprehend dyadic and network governance (Halldórsson et al, 2015).

However, for indigenous people many of the governance insights provided are based on a modernist perspective where nature does not have agency and is viewed as passive. Recently, the role and importance of the planet and nature in governance has begun to evolve in the supply chain literature (Mirzabeiki and Aitken, 2023). In contrast, the core of the Māori governance is the interconnectedness of all living things highlighting that "the relationships humans have with the nonhuman entities are reciprocal and contextual rather than unidirectional and contextual" (Reid and Rout, 2016: 429).

The purpose of this research is to understand how governance based on Māori nature interconnectedness is structured and operates. Through comprehending how supply chains can be governed through harmonious connections to the planet the paper contributes to the governance and sustainability literature.

Methodology:

Two in-depth case studies, A and B, were undertaken of agribusiness supply chains with an indigenous focal company. Given the connection that Māori have with the land, and the importance of agribusiness to the New Zealand economy, agribusiness supply chains provide a practical context for rich data collection.

Findings:

The data was analysed and categorised across two key governance areas: (1) supply chain relationships embedding relational practices and (2) the product offering reflecting contractual obligations and protection of the environment. Each of these areas were examined in the context of Māori nature interconnectedness and how this facilitated or hindered governance development in the wider supply chain.

Whilst relationships were underpinned by formal contracts, social exchange and a set of shared values were at the core of chain relationships in both cases. Relational strength was seen as more important than maximising economic gains. Emotional connections that underpin business links reflected the Māori values of the focal company A with whakawhanaungatanga (establishing links and connections) and manaakitanga (hospitality) being highly regarded. To aid in promoting indigenous values and demonstrate how these are embodied throughout the focal company A invited a team from the US based distributor to New Zealand when the relationship was being established, stating, that the distributor was "… welcomed to the whanau" (family). Focal company B worked with closely with a third-party logistics provider (3PL) with both organisations sharing similar values around whanau (family), leading one respondent to state that they were a "…good cultural fit and [we] work well together".

Product quality was viewed as a tool to reinforce the brand promise sold to consumers in chain A, and a way to meet safety standards in chain B. In both chains, quality was tied to incentives (Yoo, Choi, & Kim, 2021) and brand ownership and truth (Soedarto et al, 2019). Critically both focal companies developed their supply chains based on two Māori values (1) kaitiakitanga (connection and protection of the land) and (2) the connection to cultural processes (tawa and tikanga). These values were woven into the identity of the focal companies and their people through three-day wānanga (education of Māori principles) on a marae (Māori meeting place). Producing quality products was interlinked with customary practices, including spiritual activities before harvesting, and behaviour that protected the land and sea.

Relevance/contribution:

This research investigated supply chains anchored in Māori values incorporating spiritual, cultural, social, environmental, and economic aspect. This broad and inclusive worldview contrasts with the modernist view of western centred supply chains that are concerned with rationality progress, universality, and the individual as opposed to emotion, relationships, localism and the collective (Rout & Reid, 2019). Concerns for societal and environmental well-being were found to be at the centre of the governance approach that was developed to manage relationships and controlling product quality. Māori governance reflects the growing recognition of academics that economic levers are not sufficient for sustainability. Calls for the development of governance models that incorporate a socio-ecological perspective to economic gain are growing in the academic community (Mirzabeiki and Aitken, 2023). The Māori peoples provide examples of how this can be achieved.

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Silicon Safeguards: A Supply Chain Perspective on Fab-Level Cybersecurity

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Purpose of this paper:

The purpose of this paper is to examine the evolving cybersecurity threats within the semiconductor fabrication (fab) industry and its implications for global supply chains. Given the semiconductor industry's critical role in modern digital economies (Zhu et al., 2016), any disruption due to cybersecurity breaches can (and do) have far-reaching consequences (Datta Burton et al., 2021). This research aims to understand the unique vulnerabilities of fabs (Crouch et al., 2019) and propose strategies to mitigate these risks. The study explores the interconnectedness of the global semiconductor supply chain and how cybersecurity at the fab level is a strategic imperative for safeguarding intellectual property, production integrity, and the continuous flow of goods (Ionescu et al., 2020).

This paper identifies gaps in applied knowledge, regulatory frameworks, and decision-making processes concerning cybersecurity adoption within the semiconductor supply chain (Tomlinson et al., 2022). By adopting the UK's National Semiconductor Strategy (DSIT, 2023) and Digital Security by Design (DSbD) (2024) initiatives as guiding frameworks, this study seeks to remap the contemporary cybersecurity risk landscape and enrich the conceptual understanding of semiconductors as critical components of national security and economic infrastructure. Establishing more resilient semiconductor supply chains is not just a matter of protecting individual technologies or companies; it is about safeguarding the backbone of modern society (Alsop, 2024) and ensuring the stability and prosperity of global economies and national security infrastructures.

Methodology:

This research employs our bespoke version of the Action Research (AR) methodology (Coughlan and Coghlan, 2002; Guertler et al., 2020; Maestrini et al., 2016) – that we call the 'Multi-Sided Action Research' (MSAR) framework that can account for multiple research stakeholders – to analyse and inform organizational changes in response to cybersecurity threats. This approach is rooted in Engaged Scholarship (Ven, 2007), aiming to bridge the theory-practice gap by integrating collaborative problem-solving actions with data-driven research. The study is characterized by its participatory nature (Sundarakani et al., 2021), involving key industry stakeholders such as government agencies, executives, and consultants in cybersecurity and semiconductor manufacturing.

Data collection was conducted through two rounds of semi-structured interviews, discussion panels and focus groups in the United States and Germany, targeting cyber security decision makers in the semiconductor manufacturing supply chain (regime) (Geels and Kemp, 2012). Interviewees were specifically selected (non-probability sampling), and in this case, a combination of purposive and chain-referral sampling which allowed for the inclusion of key institutional actors in the data gathering process (Tansey, 2007).

Our primary data analysis began with open coding, employing an abductive approach to leverage our expertise in technology supply chains and integrate our understanding of contemporary academic discussions on cybersecurity (Bell, Harley, and Bryman 2022). Following the initial open coding phase, we performed a cross-interview and focus group analysis to cluster more focused codes, which led to identifying the major themes (Fereday and Muir-Cochrane 2006; Vaismoradi et al. 2016; Maguire and Delahunt 2017).

MSAR emphasizes the co-creation of knowledge and value for both researchers and practitioners (Guertler et al., 2020), fostering a comprehensive understanding of cybersecurity risks across the semiconductor supply chain. Specifically, MSAR aims to demonstrate the suitability of Action Research in the fields of Supply Chain Management and Open Innovation. MSAR is underpinned by the ‘Mode 2’ knowledge production epistemology, contrasting with the traditional ‘Mode’ 1 (empirical research) approach to knowledge production, which primarily stems from academic-driven agendas. Mode 2 emphasizes collaborative knowledge creation involving both academics and practitioners, and these contrasting approaches still animate lively debates within the business research community about the rigor-relevance gap (Maestrini et al., 2016). Mode 1 scholars argue that practitioner collaboration may dilute the rigor of research, while proponents of Mode 2 point to the limited practical relevance of much of the top-tier management research over the past decade (Bartunek and Rynes, 2014; Kieser et al., 2015).

Findings:

Our findings reveal two significant themes: (1) the management of cybersecurity in supplier relationships, and (2) the integration of information technology (IT) and operational technology (OT) systems.

Diversification and Risk Exposure:

The semiconductor industry shows a marked preference for long-term supplier relationships, which facilitates deep integration crucial for complex supply chains (MacDuffie, 2011). However, post-COVID-19, geopolitical tensions, and new technology export controls, there is a heightened emphasis on supplier diversification to enhance cybersecurity and supply chain resilience (DSIT, 2023; Ivanov, 2021; Mullet et al., 2021; Sevastopulo and Liu, 2023; Spieske and Birkel, 2021). This need for diversification increases the organizational ‘attack surface,’ raising cybersecurity risks, particularly as most incidents originate within the supply chain. The industry faces the challenge of balancing stable partnerships with the necessity of diversifying suppliers to mitigate risks.

The IT/OT Dichotomy:

Historically, Information Technology (IT) systems (focused on managing information through computers and software) and Operational Technology systems (concerned with controlling physical processes through hardware and software) evolved separately, each with distinct priorities and protocols (Hahn, 2016). Today’s cybersecurity threats, however, demand a convergence of these systems. The semiconductor industry, with its advanced and highly integrated processes, is at the forefront of defining how IT and OT integration can enhance cybersecurity defences.

These themes underscore the complex balance required in managing cybersecurity in the semiconductor fabs, necessitating innovative strategies that emphasize flexibility, collaboration, and a robust understanding of the cybersecurity landscape.

Value:

This paper contributes valuable insights into the critical but underexplored area of fab-level cybersecurity within the semiconductor supply chain. Its originality lies in the application of the MSAR methodology to cybersecurity and supply chain research, offering a novel perspective on engaging with complex, multi-tiered supply chain vulnerabilities. The study's value extends to stakeholders across the semiconductor industry, including policymakers, cybersecurity professionals, and supply chain managers, by providing actionable strategies for enhancing cybersecurity resilience. It also enriches the academic discourse around semiconductor supply chain cybersecurity and serves as a foundational piece for future research in this critical area of supply chain technology management.

Research Limitations:

This research is subject to some limitations, including the scope of data collected within the sector and the generalizability of findings due to our non-probability sampling method.

Theoretical & Operational Implications:

Theoretical implications point to the need for further interrogation of the IT and OT dichotomy, while the practical implications of this research are significant for the semiconductor industry, emphasizing the need for a robust cybersecurity ecosystem that includes third parties and suppliers, who account for two thirds of cybersecurity incidents.

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Globalisation of Supply Chains

Establishing Backward Linkages in Indian Pharmaceutical Supply Chains

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Purpose of this paper:

Indian pharmaceutical industry known as the 'Pharmacy of the developing world' exports 60% of global vaccines to over 150 countries and accounts for 20% of the supply of generics by volume. It is valued at $50 billion in 2023 and is expected to reach $65 Bn by 2024 and to $130 Bn by 2030 (Investindia, 2024). To meet the needs of growing demand, it is important for the Indian pharmaceutical industry to embark on building resilience in the supply chain. One of the ways of building resilience in pharmaceutical supply chains is to ensure the continuous and uninterrupted supply of raw materials (Lücker & Seifert, 2017; Yaroson et al., 2021). Raw materials such as active pharmaceutical ingredients (APIs), key starting materials (KSMs), and intermediates used in manufacturing pharmaceutical products referred to as the bulk drugs industry is the backbone of the pharmaceutical industry.

Indian pharmaceutical industry is severely impacted by the COVID-19 pandemic with more than 70 percent of APIs sourced from China. Since the pandemic, developing backward linkages in Indian pharmaceutical industry has become a strategic priority for both policy makers and pharmaceutical firms. While supply chain management in pharmaceutical industry is an area with immense research interest, challenges related to raw material sourcing have not gained much attention Pattnayak & Thangavelu. 2011; Yaroson et. al., 2021). Hence this study aims to identify the challenges and develop strategies in establishing backward linkages in Indian pharmaceutical industry.

Design/methodology/approach:

Developing backward linkage in Indian pharmaceutical industry starts with the establishment of bulk drug industry through inshoring manufacturing facilities to India and then managing the relationships between the manufacturers and bulk drug industry. In this study, we are using ownership-location-internalisation (OLI) framework. Dunning (1981) identified ownership, location, and internalization advantages as the determinant groups that explains why firms choose to produce in an international location. Determinants of international production would infer that they are the challenges of moving back the production facilities to the home country (i.e., inshoring) and establishing relationships among the supply chain members. Underlined by OLI framework, a conceptual framework with sixteen challenges organised into ownership, location, and internalisation challenge-categories is developed in this study.

DEMATEL is an effective procedure that delivers valuable information for decision making about the problems with complex interdependencies. Hence DEMATEL approach is considered an appropriate method for the study. Using convenience sampling approach this study collects data from eight large firms manufacturing pharmaceutical products in India. Among the eight firms, three firms are leading the industry with market capitalisation over $206 billion while the other five firms have a market capitalisation between $0.36 billion and $10 billion. As the three firms are very large in size, we interviewed two respondents from different business divisions and one respondent from each of the five firms adding up to eleven interview respondents. Using a three-part questionnaire structured interviews were conducted for approximately 60min. Responses to pairwise comparison questions on relationship between backward linkage challenges were used to conduct DEMATEL analysis and draw a cognitive map.

Findings:

Results indicate that the scale of operations, infrastructure, financial resources of the ownership challenge-category, macro-economic factors, and market characteristics of the location challenge-category are the top five critical challenges. Based on the 'level of criticality' and 'level of influence' values computed from DEMATEL, challenges are clustered into 'Vital Driver', 'Non-vital Driver', 'Vital Driven', and 'the Non-vital Driven' category. Results indicate that macroeconomic factors, business alliance, and information sharing are the Vital Driver challenges. Issues with human resources, government regulations, supplier knowledge management, competitive pressure, raw material access, and switching costs are Non-vital Driver challenges. Inadequate infrastructure, scale of operations, financial resources, and market characteristics as the Vital Driven challenges. Finally, technology capabilities and business process are considered as the Non-vital Driven challenges.

Understanding the relationships between the challenges presented in cognitive map assists in providing realistic assessment of the challenges. Results indicate that there are 18 direct relations between the challenges above the threshold value. In addition, to the direct relationships between the challenges there are certain challenges that can be indirectly influenced through the other challenges forming loops. One such relationship is macro-economic factors impacting scale of operations through infrastructure availability. i.e., it is understood that the increase in availability of the low-interest rate loans for the establishment of the firms in bulk drug industry would address the issues related to the infrastructure thus promoting the firm's ability to produce pharmaceutical products in bulk and achieve economies of scale.

Value:

Literature on examining reshoring challenges is focused on the RBV and TCE. All these theories focus on the ownership aspect (i.e., sourcing) rather than the location aspect (i.e., shoring) thus limiting the explanation of reshoring. Hence, the use of OLI expands the factors beyond the core competencies and costs to location aspects. Meanwhile, internalisation element of OLI framework provides the nature and boundaries of organisations. In general, the internalisation aspect is used to examine how multinational enterprises evolve to internalise the resources to maintain competitive advantages. Incorporating elements of supplier relationship management as an element of internalisation extends the internalisation within organisation to internationalisation at supply chain level.

Research limitations/implications:

The major limitation is the study context. The results were obtained by focusing on the Indian context and therefore may not be applicable to other developing nation contexts. In the future, more research is needed in other developing countries. Moreover, the sampling technique adopted in the study is convenience sampling where respondents from large firms operating in India who are sourcing from overseas bulk drug suppliers are interviewed. So, the results obtained may not be applicable to the small and medium firms. Therefore, to provide a holistic understanding of pharmaceutical backward linkages, future research needs to consider the views of the firms of all sizes, including those of small size to identify other critical challenges.

Practical implications:

This research contributes to the literature in two ways. First, this is the first of its kind study to investigate and categorise the backward linkage challenges of pharmaceutical manufacturers. Prioritising and categorising the identified challenges will assist in developing strategies that promote and strengthen the backward integration in the pharmaceutical supply chains. Second, examining the backward linkages in the Indian pharmaceutical industry assists the world's third largest pharmaceutical exporter (i.e., Indian pharmaceutical firms) to retain its position as a reliable supplier. An uninterrupted supply of the pharmaceutical products from Indian pharmaceutical companies is crucial for the wellbeing of the world population.

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Supply Network Mapping: Development of a region-centric Approach

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Purpose of this paper:

Supply chains are subject to constant change and adaption due to various influential factors. While some factors are intentional and internally driven, e.g. a company's strive for continuous improvement, many factors are not. In the last two decades, we have witnessed a considerable amount of major events where supply chains were disrupted and thus forced to be adapted in a rather unintentional and unplanned manner. Some of the most significant recent examples are the Brexit, which especially lead to regulatory issues; the Covid-19 pandemic, which, amongst other aspects, lead to health hazards, staff shortages, and a drastic change in demand; as well as the war between Russia and the Ukraine, which heavily impacted the procurement and sales landscape (Handfield et al., 2020). These events yet again emphasized the need for and importance of accurate supply chain mapping as it is considered the first stepping-stone for transparent and effective strategic supply chain management (MacCarthy et al., 2022). This is also reflected in current research as supply chain mapping has seen a significant increase in attention (MacCarthy et al., 2022). However, supply chains can be mapped within different scopes, which are not equally covered in current literature. It is evident that most research focuses on either detailed, individual company level mapping (e.g. Kito et al., 2014), or on global, macro-economic mapping addressing a specific country, industry, or product (e.g. Frederick, 2019). Region-centric mapping approaches that cover supply chains across a region's companies and industries, so-called supply networks, are not addressed at all depicting a clear research gap. Thus, this paper aims to expand knowledge regarding the possibilities of region-centric supply network mapping in terms of conceptual design as well as its applicability for potential stakeholders like the region's governmental institutions and policy makers.

Methodology:

To reach the given objective, this paper uses the design science research process (DSRP) model as defined by Peffers et. al. (2020) and further specified by Hevner et. al. (2004). This design- and construction-oriented process model allows to systematically and transparently develop an approach for supply network mapping. As foundation for designing the approach, prior literature addressing neighbouring disciplines such as supply chain mapping (company level) or global value chain mapping (macro-economic level) is used. The design is then demonstrated and evaluated through an illustrative case study in which a supply network map is created for a model region, in this case, the district of Steinfurt, Germany.

Findings:

Developing a region-centric supply network mapping approach is subject to two central challenges: Firstly, current research, which is aimed to serve as foundation as mentioned above, consists of rather distinct and individual mapping approaches while lacking standardized procedures. Consequently, an informed selection of pertinent aspects to serve as basis is to be made and overarching principles are to be identified. Secondly, the inherently cross-industry nature of the region-centric mapping project poses constraints on data availability, necessitating the development of different methods than those used in the previously mentioned approaches to unveil a region's supply network in an accurate yet time-efficient manner, a theme that will be explored in this work.

Value:

By constructing and operationalizing a novel approach for region-centric supply network mapping, this paper takes the first step towards filling the initially identified research gap.

The artifact designed in this paper can be utilized by governmental institutions, policy makers, and businesses alike to enhance transparency over current geographic and systemic interdependencies as well as for activities encompassing the comprehensive identification of supply chain risks on an broader scale in order to support a region's or business's resilience.

Research implications:

The research conducted in this paper explores a new area of supply chain mapping by providing an initial approach. To further enhance its accuracy, reliability, and applicability, further refinement and validation of the proposed procedure is imperative. This includes but is not limited to the conduction of further case studies with other model regions.

Practical implications:

Governmental institutions and policymakers can incorporate the insights from the mapping approach into regional development plans and policies, fostering economic growth, resilience, and sustainability. Furthermore, businesses can leverage the proposed mapping approach to gain transparency and increase understanding of regional dependencies with regards to their operating environment allowing to make informed decisions regarding supply chain optimization and resource allocation.

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Managers' resource orchestration and reshoring decision making: evidence from multinational enterprises in China

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Purpose of this paper:

The literature on reshoring extensively discusses various drivers and strategies, encompassing country-specific and/or efficiency-driven initiatives, geopolitical tensions, value considerations, job creation, and national security concerns (Nandi et al., 2021; Strange, 2020; Ancarani and Di Mauro, 2018). However, there exists a notable gap in addressing the perspective of firms, particularly the role of managers and their capability in dynamic resource orchestration, and how this impacts reshoring decision-making.

Moreover, recent research confirms the significance of tangible reshoring drivers such as total cost, market dynamics, and infrastructure facilities, particularly in times of disruption. However, limited attention has been given to intangible factors such as culture, human capital, policies, and regulations. This gap underscores the need for a more comprehensive understanding of the multifaceted influences on reshoring decisions.

Drawing upon the resource orchestration theoretical (ROT) perspective, this study aims to analyze managers' capabilities and their role in reshoring decisions. It seeks to extend the understanding of the significance of intangible factors in resource orchestration and proposes future research directions in this domain.

Design/methodology/approach:

The study conducts a thorough literature review, scouring major research databases using search strings such as 'reshoring,' 'backshoring,' 'reshoring drivers,' and 'reshoring factors.' It categorizes the drivers influencing reshoring decisions into tangible and intangible factors. Employing Q-methodology, the research prioritizes the viewpoints of managers from multinational manufacturing firms regarding their reshoring decision-making process.

Multiple responses from 14 multinational manufacturing firms based in China are classified to pinpoint the critical motivational factors guiding reshoring decisions made by managers. This approach enables a nuanced understanding of the complex dynamics at play in reshoring strategies within the context of multinational manufacturing firms.

Findings:

The study delves into the crucial decision factors shaping managers' efforts to coordinate both internal and external resources, aimed at achieving value creation objectives within their firms' parent locations. Intriguingly, the findings reveal that intangible factors, particularly culture, exert a more significant influence than tangible categories like quality control and productivity in the reshoring decision-making process for firms situated in China. This highlights the nuanced interplay between cultural considerations and strategic decisions, shedding light on the complexities of reshoring strategies within the Chinese business landscape.

Value:

The study contributes significantly to reshoring literature by illuminating managers' roles and perspectives regarding the factors that shape strategic reshoring decision-making—a crucial area that has received scant attention in existing research. Furthermore, it extends

the resource orchestration theory by examining managerial decision-making processes within the context of reshoring strategies. This expansion of theoretical frameworks offers valuable insights into the complex dynamics underlying reshoring decisions and underscores the importance of considering managerial perspectives in understanding and formulating effective reshoring strategies.

Research limitations/implications:

While the study provides valuable insights, its scope is confined to multinational manufacturing firms in China. This narrow focus on a specific country and industry sector may constrain the generalizability of its findings. To address this limitation, future research should broaden its scope to investigate reshoring factors in the context of service operations sectors. Additionally, exploring scenarios such as nearshore locations and reshoring to internalize formerly outsourced activities would offer a more comprehensive understanding of reshoring dynamics across different contexts. Expanding the study in these directions would enrich the scholarly discourse and provide practical implications for a wider range of industries and geographical regions.

Practical implications:

The study's findings hold significant implications for policymakers and researchers, offering valuable guidance in the development of industrial policies and regulations. By aligning these policies with managers' key concerns and inclinations towards reshoring, policymakers can foster an environment conducive to reshoring initiatives. Moreover, researchers can leverage these insights to delve deeper into the factors influencing reshoring decisions, ultimately contributing to the formulation of more targeted and effective policies. This collaborative effort between policymakers and researchers is essential for promoting sustainable economic growth and competitiveness in today's globalized marketplace.

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Logistics Connectivity

Challenges facing Vietnam's rail transport system in providing Effective logistics services for the national economy

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Purpose of this paper:

The Socialist Republic of Vietnam, an authoritarian state ruled by the Communist Party, has been a development success story. In 1986, t*he Doi Moi* launched new reform policies (its name means "restoration"), which led to far-reaching changes. From a country faced with the prospect of a serious economic collapse, Vietnam has become a fast-growing market. The study addresses the relationship between rail transport infrastructure – a component of the logistics system and economic development, its aim is to diagnose the state of Vietnam's railways infrastructure so the needs can be determined in terms of undertaking infrastructure projects to improve its efficiency, productivity, and economic utility. One of the necessary conditions to obtain multiplier effects (for example, strengthening the accessibility of the market, including local markets, attracting and intensifying investments, and supporting employment) is an efficient transport system. It must function at the right level (from logistical and economic perspectives) to ensure the desired capacity and reliability.

Design/Methodology/Approach:

The study was conducted in the first half of 2023 using source analysis (literature review), participant observations and interviews with experts – representatives of the sector. The collected research material includes numerical data, including data obtained from internal, unpublished databases of the Vietnamese Railways, and very extensive photographic documentation reflecting the current state of the rail transport sector.

Findings:

Vietnam has a favorable position for the development of logistics. This is due to not only its geographical location but also its geographical factors, especially its coastline of 3,260 km running along the whole length of the country. The coastal areas of Vietnam have many large rivers pouring into the sea, creating favorable conditions for the construction of seaports. The data of the Vietnam Maritime Administration show that the total country port capacity is 550 million tons/year. Such a long coastline along the South China Sea, one of the most important maritime trade routes in this part of the world, creates factors that favor the development of logistics services. These, however, require an appropriate, modern, efficient, and productive rail system.

Railway infrastructure in Vietnam is considered backward and weak compared to infrastructure in other countries in the region. Vietnam's transport capacity is generally lower than desired due to its small scale and lack of modernization. This situation certainly requires additional expenditure due to additional challenges in the construction and maintenance of trails in more difficult engineering conditions (geological: mountainous areas, sections along rivers and streams). The railway transport system shows significant exploitation, both in terms of linear and nodal infrastructure, as well as rolling stock. In the system of Vietnamese seaports, only Hai Phong Port is well-connected to the railway, but the operation efficiency is very low (Cai Lan Port has been invested in but has not been able to operate due to a lack of a synchronous gauge) with no highways, particularly for freight transport.

Railways are the mode of transport that requires the most urgent large-scale investment. Over the years, the state has encouraged investment in railways. However, investors are not interested. Therefore, the investment in railway field development needs the state's steadiness in infrastructure investment, and some items, such as stations, may require the private exploitation and localization of some urban railway lines.

Value/Originality:

The study was conducted during a research internship in Vietnam using triangulation of sources. The results are up-to-date and reflect the existing state of affairs, thus providing a basis for formulating conclusions and practical recommendations.

Research Limitations/Implications:

The study focused on the functioning of one mode of transport (rail transport) and is based on data collected "on the ground". This does not mean, however, that the analysis of the current state does not refer to other, alternative modes of transport, after all, the issue of the functioning of the Vietnamese road transport system was also taken into account in the analysis. The conclusions from the first phase are a starting point for further research covering the specific needs in the development of Vietnam's logistics infrastructure. The intention of the research (in total) is to identify the scope of activities and assess the degree of their implementation to ultimately increase the efficiency of logistic services for economic processes in the logistics corridors running through Vietnam.

Practical Implications:

Demonstration of the degree of underdevelopment of the railway sector, which is especially visible against the background of the development of the road sector, can be used to articulate specific investment needs and the development program of the national railway transport system. The railways are naturally predestined to service the increasing transport needs of a growing economy of Vietnam, including the needs resulting from the increase in international trade in goods with neighboring countries.

Sustainable innovations in supply chain services - the case of Polish and Slovak Logistics Service Providers (LSPs)

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Propose of this paper:

LSPs operating in today's economy face numerous challenges in implementing innovations in the logistics service they provide and offer. In addition to the increasing demands of customers, the pressure on LSP's to demonstrate greater commitment and activity in terms of sustainability and environmental performance plays an important role. Undoubtedly, the uniqueness of innovation in logistics, is expressed in the form of two characteristics, which are the scope of its application and the extent to which its effects will spread. This is also reflected in the objectives pursued, not only economic, but also anchored in sustainable development practices (Bouchette et. all., 2018). The aim of this article is to present selected results of empirical research indicating identified types of innovations introduced by Polish and Slovak LSPs (3PLs and 4PLs), in relation to innovations related to sustainable development (CSR, ESG more broadly). This article discusses how logistics service providers (LSPs) can positively contribute to environmental protection and value creation by implementing environmental, social and governance (ESG) guidelines. By implementing innovative solutions, LSPs can reduce their carbon footprint, promote resource efficiency and mitigate the environmental risks associated with their operations. Furthermore, implementing environmental innovations can also increase the overall value of logistics services, as these activities can attract environmentally conscious customers and investors.

Design/methodology/approach:

The methodology of the conducted research adopted a multi-stage approach. The first stage included a systematic review of the literature, according to the procedure proposed by Tranfield, Denyer and Smart (2003). The results of the systematic literature review confirmed the need to conduct further research on this issue. Hence, the second stage was focused on conducting empirical research using qualitative methods, such as Delphi and Case Study. The case study method adopted the concept proposed by R.K. Yin (2017), both in terms of methodology and the definition of a case study. It was decided to conduct individual case studies. The Delphi method was used bearing in mind that it involves structuring the process of group communication, which enables a group of independent people to jointly solve a complex problem (Linstone, Turoff, 1975), and also bearing in mind that the knowledge and experience of those participating in the study determine the reliability of the results of the Delphi study (Hasson, Keeney, 2011). Experts include scientists, representatives of business practice, specialists in a given field (area) and those with significant knowledge of the examined issue (McKenna, 1994). Hence, 23 experts from Poland and Slovakia took part in the Delphi study. However, in the case study, the research covered the largest LSPs in Poland and Slovakia, which were 11 of the largest LSPs in Poland and Slovakia.

Findings:

The results of the study showed that LSPs show a high level of commitment to implementing innovations, particularly innovative environmental and CSR(ESG) activities. These activities appear to be a driving force, positively influencing the environment. The literature indicates that green innovation promotes environmental efficiency, minimizes waste, and enables cost savings, and thus efficiency and synergies between business partners (Chieh-Yu Lin, Yi-Hui Ho, 2008). Furthermore, the findings correspond with the literature review, which confirms that environmental aspects of CSR are an extremely important element of an LSPs business offering, and will become increasingly important as a criterion in the selection of LSPs (Wolf, Seuring, 2009; Björklund, Forslund, 2013).

Practical implications:

The results of the research can serve as a contribution to improving the implementation of environmental activities for LSPs, who can compare and adapt their concepts to the practices described in the article.

Originality/value:

The findings presented in this area can be seen as a voice in the discussion opening up the possibility for further in-depth exploration and inference. It should also be pointed out that limitations and necessary directions for further future research have been identified.

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A Systematic Literature Review Approaches towards Sustainable Ports in the Gulf: A Focus on Saudi Arabia and UAE

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Purpose of this paper:

This project explores the concept of port sustainability and addresses key gaps and challenges in achieving sustainable practices within the maritime industry. In the study, a total of 25 articles identified through a systematic review approach was done under two major themes, that is on use technology to achieve port sustainability and use of green initiatives. Based on the articles analysed, this study identified three critical areas of concern: the absence of standardized key performance indicators for port sustainability, the challenges faced by ports in adopting sustainable initiatives, and the influence of individual factors on port performance, such as geographical location. By analysing these gaps, the project emphasizes the need for collaborative efforts among port authorities, shipping companies, government bodies, industry associations, and research institutions to promote sustainable practices and address environmental and social impacts.

Keywords: sustainable ports, digital ports, smart ports, green ports, Middle East, Gulf ports, Saudi Arabia, UAE

Analysis of ESG Performance Factors of Logistics Service Providers in Taiwan

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Purpose of this paper:

The primary aim of this research is to investigate the Environmental, Social, and Governance (ESG) performance factors that influence the operational performance of Logistics Service Providers (LSPs) in Taiwan. The study seeks to understand the relationships between these ESG factors and overall/financial performance among LSPs in Taiwan. This is crucial because sustainable business practices are increasingly recognized as vital for long-term success and competitiveness in the logistics industry. By assessing how ESG factors impact operational performance, the research aims to provide valuable insights for LSPs and other stakeholders, helping them make informed decisions and improve their sustainability practices.

To achieve these aims, the research adopts a mixed-method approach, combining qualitative interviews with expert professors in the field with quantitative survey data analyzed using the Analytic Hierarchy Process (AHP) method. The use of both qualitative and quantitative methods allows for a comprehensive understanding of the complex relationships between ESG factors and operational performance in Taiwan's logistics industry. By leveraging expert insights and systematic analysis, the study aims to contribute to the existing literature on sustainable business practices in the logistics sector and offer practical recommendations for enhancing ESG performance and overall competitiveness among LSPs.

Design/methodology/approach:

The objectives of this research are achieved through a mixed-method approach that combines qualitative interviews with expert professors in the field and quantitative survey data analyzed using the Analytic Hierarchy Process (AHP) method.

Firstly, qualitative interviews with expert professors serve to gather in-depth insights into the Environmental, Social, and Governance (ESG) performance factors relevant to the logistics industry in Taiwan. These interviews help validate the survey instrument developed for the quantitative phase of the study and ensure its alignment with expert knowledge and industry standards.

Secondly, the quantitative survey is designed to measure respondents' perceptions and practices regarding ESG factors and overall/financial performance among Logistics Service Providers (LSPs) in Taiwan. The survey instrument captures a wide range of ESG criteria and allows for systematic data collection from a diverse sample of industry stakeholders.

The collected survey data are then analyzed using the Analytic Hierarchy Process (AHP) method. AHP is a structured decision-making tool that enables the systematic evaluation and prioritization of multiple criteria and alternatives. By applying AHP analysis to the survey data, the relative importance of different ESG factors in influencing corporate operational performance among LSPs in Taiwan is determined.

Overall, the research approach involves both qualitative and quantitative methods to provide a comprehensive understanding of the complex relationships between ESG factors and operational performance in the context of Taiwan's logistics industry. The theoretical scope of the paper encompasses sustainable business practices, ESG considerations, and operational performance within the logistics sector, with a specific focus on the Taiwanese market.

Findings:

During this research, several key findings emerged regarding the relationship between Environmental, Social, and Governance (ESG) performance factors and operational performance among Logistics Service Providers (LSPs) in Taiwan.

The qualitative interviews with expert professors revealed valuable insights into the specific ESG factors that are most relevant and impactful within the Taiwanese logistics industry. These factors include environmental considerations such as carbon emissions reduction initiatives, social aspects like labor practices and community engagement, and governance practices such as transparency and ethical leadership.

The quantitative survey data, analyzed using the Analytic Hierarchy Process (AHP) method, provided further clarity on the relative importance of these ESG factors in influencing the operational performance of LSPs in Taiwan. The analysis revealed that while all three dimensions of ESG (environmental, social, and governance) are important, certain factors may have a more significant impact on operational performance than others. For instance, the survey results may indicate that environmental factors such as energy efficiency measures or waste reduction initiatives have a stronger correlation with financial performance compared to social or governance factors.

Overall, the findings suggest that there is a nuanced relationship between ESG performance and operational outcomes in the Taiwanese logistics industry. By identifying the key drivers of performance and their relative importance, the research provides actionable insights for LSPs and other stakeholders seeking to enhance their sustainability practices and overall competitiveness. These findings contribute to the growing body of literature on sustainable business practices in the logistics sector and offer practical recommendations for fostering environmental stewardship, social responsibility, and good governance practices in Taiwan's logistics industry.

Value:

Thios paper’s contributions lies in its comprehensive examination of the relationship between Environmental, Social, and Governance (ESG) performance factors and operational performance among Logistics Service Providers (LSPs) in Taiwan. By integrating qualitative insights from expert interviews with quantitative analysis using the Analytic Hierarchy Process (AHP) method, the research offers a nuanced understanding of the complex dynamics at play within the Taiwanese logistics industry. This approach contributes to the existing literature by providing empirical evidence and actionable insights that can inform decision-making processes for LSPs, policymakers, investors, and environmental advocates. The value of the paper extends to stakeholders interested in promoting sustainability, fostering corporate responsibility, and enhancing competitiveness in Taiwan's logistics sector.

Limitations and Future Research Directions:

While this study provides valuable insights into the relationship between ESG performance factors and operational performance among Logistics Service Providers (LSPs) in Taiwan, it is not without limitations. One limitation is the reliance on self-reported data, which may introduce bias or inaccuracies. Additionally, the scope of this research is limited to the Taiwanese logistics industry, and findings may not be generalizable to other regions or sectors. Future research could explore these relationships in different contexts and industries, as well as employ longitudinal studies to examine the long-term effects of ESG practices on operational performance.

Practical Implications:

The findings of this study have several practical implications for stakeholders in the logistics industry. LSPs can use the insights gained from this research to inform their sustainability strategies and enhance their competitive advantage. Policymakers and regulators can leverage these findings to develop targeted policies and incentives that promote sustainable business practices within the logistics sector. Investors and financial analysts can incorporate ESG performance metrics into their investment decisions to assess the long-term viability and risk profile of LSPs. Ultimately, the adoption of ESG principles can lead to improved environmental stewardship, social responsibility, and governance practices within the logistics industry.

Acknowledgments:

The authors would like to acknowledge the support and contributions of the expert professors who participated in the interviews for this study. Their valuable insights and expertise greatly enriched the research process and findings.

Concluding Remarks:

In conclusion, this study advances our understanding of the complex relationships between ESG performance factors and operational performance in the Taiwanese logistics industry. By combining qualitative insights with quantitative analysis, this research provides a comprehensive framework for evaluating and improving sustainability practices among LSPs. Moving forward, continued efforts to integrate ESG considerations into business strategies and decision-making processes will be essential for promoting environmental stewardship, social responsibility, and good governance practices within the logistics sector.

Smart Strategic and Operational Gate Optimization at the King Abdullah Port in Saudi Arabia for Efficiency

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Purpose of this paper:

The purpose of this study is to analyze the flow of container trucks from the terminal gate and compare the current gate system with the smart gate system to find a sustainable solution to maximize the current resource utilization, reduce waiting time, and secure, transparent, hassle-free clearance that contributes to cost reduction. Due to the increase in trade volume with the Kingdom of Saudi Arabia, there is a need for the deployment of a smart gate system to improve operational efficiency, decrease waiting times, and satisfy the expectations of a competitive market.

Design/Methodology/Approach:

The study takes a broad approach, examining how the container gate system is currently operating. This entails identifying the input components and the relationship between truck trips and container volume. A waiting cost, fixed cost, and labor cost model is used to calculate the economic costs of gate congestion. The study also compares congestion levels and gate capacity, which offers insights into possible process enhancements and optimization techniques. To accomplish these goals and evaluate the paper's theoretical and practical scope, the methodology uses data analysis, modeling strategies, and performance measurement techniques.

Findings:

Although the existing gate capacity is greater than the business requires, there is still plenty of room for development. Implementing a smart gate system in conjunction with improvements made to the Port Community System and performance metrics like yard productivity and truck turnaround time can result in significant cost and efficiency savings.

Value:

To improve operational efficiency at ports and optimize transportation movement, this study presents innovative approaches and technologies such as Intelligent Traffic Management Systems, Real-Time Data Analytics, and Advanced Terminal Operating Systems. Its significance lies in its ability to direct stakeholders and port operators in implementing workable ideas to alleviate congestion and enhance overall performance.

Research Limitations/Implications:

Future studies should examine how the shipping sector is affected by new trends, including disruptive technologies, such as artificial intelligence-based learning, data-driven decision-making, machine learning, deep learning, e-commerce, digitalization, emission control, and decarbonization. The use of automation and technology to reduce human error, shorten chilled container stay periods, and speed up truck turnaround times are further practical ramifications.

Practical Implications:

According to the research, enhancing efficiency and safety in port operations requires a strong use of technology, notably automation. By utilizing high-speed communication, reducing data entry mistakes, and shortening container dwell times, ports may improve key performance indicators and sustain their competitiveness in the global market.

Keywords: Port Optimization, King Abdullah Port, ZAWIL Border Guard System, Container, Red Sea, Smart Gate, FASAH Customs platform for clearance of cargo, Saudi Arabia.

Regional Logistics Linkage: Toward an Analytical Framework

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Purpose of this paper:

Collaboration is at the heart of supply chain operations and is one of the most extensively studied topics in logistics and supply chain management research. The majority of the studies on supply chain collaboration, however, tend to concentrate at the micro level (i.e., between businesses in the logistics ecosystem), in which information sharing, goal congruence, incentive alignment, and decision synchronisation have been identified as key enablers (Cao and Zhang, 2011). Very little supply chain collaboration research exists at the macro level (i.e., between administrative units in the same geographical region, or between economic regions in the same country). UNESCAP (2014) contend that macro-level supply chain collaborations are essential to enhancing regional logistics linkages and their socio-economic development. To address this gap, this paper develops an analytical framework of regional logistics linkages to stimulate supply chain collaboration research at the macro level.

Design/methodology/approach:

Our conceptualisation of the analytical framework of regional logistics linkage is rooted in the interface of two major management theories: stakeholder and general system theories. The stakeholder theory, advocated by Freeman (1984) and associated with the Resource-based View (RBV) (Barney, 1991; Wernerfelt, 1984), argues that multiple constituencies, such as employees, suppliers, local communities, and authorities, are impacted by the business practices in the regions and thus should be included in their design. Since agents in a region's logistics ecosystem are linked by a complex web of relationships, both at the micro and macro levels, understanding their collaboration calls for a conceptual lens that could shed insights into the complex phenomena emerging from those interactions. The General System Theory (von Bertalanffy, 1950), or GST, which views all phenomena as a web of relationships among elements to form an interdependent system, offers an appropriate conceptual lens to guide the moulding of our proposed analytical regional logistics linkage framework.

Findings:

Since regional logistics linkages occur at both micro and macro levels, our proposed analytical framework includes components at both levels. At the micro level, enhancing regional logistics linkage can be achieved through information sharing, goal congruence, incentive alignment, and decision synchronisation, not only between businesses in the logistics ecosystem within an administrative unit but also between units within the same geographical region. These collaboration enablers at the micro level are interrelated, jointly contributing to increasing regional logistics linkages. For example, sharing relevant information accurately, completely, and promptly will help promote goal congruence among supply chain partners, and having aligned goals will help make incentive alignment easier.

At the macro level, we posit that four important factors contribute to increasing regional logistics linkages: infrastructure optimization, institutional synchronisation, process and system alignment, and standardisation of human resource development among administrative units within the same geographical region. Similar to their counterparts at the micro level, collaboration enablers at the macro level are also closely interrelated, constituting the backbones of regional logistics linkages. For example, institutional synchronisation will allow authorities in administrative units within the region to leverage each other's logistics infrastructure and align their processes to achieve efficiency gains. The operational synergy thus created will engender favourable conditions for businesses in the regional logistics ecosystem to operate as a unified whole, strengthening regional logistics linkages. Collaboration enablers at the micro and macro levels will also form a symbiotic relationship among them, supporting each other like gears in a machine, thus fortifying regional logistics linkages in the process. For instance, when businesses in the same logistics ecosystem agree to synchronise their decisions and share benefits and risks, process alignment will be facilitated, creating, in turn, a foothold for further decision synchronisation, leading to other collaborative incentives, including incentive alignment.

The aforesaid analytical framework and its components can be applied for the appraisal of regional logistics linkage in regions with significant national socio-economic impacts such as the Southeastern region of Vietnam, established by the Polibureau Decree No. 24-NQ/TW (Chinh Phu, 2022).

Value:

This research relates supply chain collaboration issues at the micro with the macro level through an integrated analytical framework. Apart from expanding knowledge on logistics and supply chain collaboration from the micro to the macro level to introduce the concept of regional logistics linkages, this research also widens the application of the stakeholder and general system theories in the logistics and supply chain management domains.

Research limitations/implications:

While there are potential academic and practical contributions, this research is constrained in its current format of a conceptual analytical framework. Empirical validation in future research would help to confirm its venerability reliability and validity.

Practical implications:

This research has two prospective practical contributions. First, such an analytical framework could assist policy makers evaluate regional logistics linkages objectively, helping to identify bottlenecks that could weaken those linkages. Ineffective regional logistics linkages have been shown to dampen regional socio-economic connectivity, hampering regional development and eventually the country as a whole (UNESCAP, 2014). The proposed analytical regional logistics linkage framework offers an overarching structure to guide the formulation of regional development policy. Secondly, businesses in the regional logistics ecosystem can employ this analytical framework to appraise the regional impacts of their existing collaboration practices and implement relevant rectification measures to both optimise the benefits accrued from these linkages and strengthen their contributions to expanding them.

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Planning future infrastructure to support transition to sustainable Heavy Goods Vehicle operation in Scotland: An agent-based simulation approach

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Purpose of this paper:

The land-based freight transportation plays a crucial role in the UK's economic prosperity, yet it poses a considerable environmental challenge due to greenhouse gas and harmful emissions. Heavy Goods Vehicles (HGVs) account for 90% of goods transported domestically in the UK (DfT, 2018), and it currently represents about 5% of UK’s total GHG emissions (BEIS 2020). To achieve net-zero carbon emissions in long-haul transportation, the UK urgently needs adopt zero-emission alternatives to conventional diesel-powered HGVs such as battery electric vehicle (BEV) or hydrogen fuelled vehicle (HFV).

The transition faces uncertainties as new technology adoption hinges on road infrastructure. Thus, strategic placement of recharging and refuelling facilities is crucial to enable fleet operators to maintain standard operations without a substantial rise in costs. This paper report initial results from a six-month project aimed at assisting the government and stakeholders in facilitating a seamless shift to BEV and HFV. It focuses on freight transportation by Heavy Goods Vehicles (HGVs) within Scotland, covering both long haul (over 8 hours) and short haul (3-4 hours) journeys. The project aims to:

1. To determine where to develop charging or refuelling facilities and specifying the corresponding capacity at each facility.
2. Providing advice to investment and funding bodies of which location should be prioritised and inform appropriate schedule of deployment.

Design/methodology/approach:

This research employed an agent-based simulation approach to investigate optimal infrastructure placement for sustainable HGVs in Scotland. To initiate this process, stakeholder engagement was crucial. A dedicated meeting convened key figures from the transportation sector, including energy providers, truck manufacturers, city councils, and fleet operators. This collaborative effort fostered discussions on the challenges and opportunities surrounding infrastructure development for sustainable HGVs. It also served the valuable purpose of obtaining baseline data, which would inform the subsequent stages of the research.

Following stakeholder engagement, data collection efforts were undertaken. Operational data encompassing a substantial 93,000 routes traversed over a year was secured from five organizations. These organizations represented diverse sectors within the transportation industry, including national retailers, a logistics company, a food distributor, and a local authority. The data encompassed details on both planned and actual journeys, alongside vehicle tracking information and aggregated flow data. Once collected, the data underwent rigorous processing steps. This involved removing very short stops likely caused by traffic congestion to ensure accurate representation of travel patterns. Additionally, data fusion techniques were employed to guarantee consistency across the various data formats used by the participating organizations (e.g., unifying location IDs).

The processed data was then integrated into a Java-based agent-based modelling environment. This environment allowed for simulating real-world scenarios and analysing their impact on infrastructure needs for sustainable HGVs. The model further incorporated existing infrastructure elements across Scotland, such as warehouses, depots, and gas stations. Additionally, potential hydrogen refuelling sites identified in a previous study by Raeesi et al. (2024) were also included within the model to provide a comprehensive picture of the current and potential future infrastructure landscape.

It's important to acknowledge the limitations of the acquired data. While the volume of routes analysed is significant and spans a year, it represents a small sample compared to the total HGV population in Scotland. Furthermore, the data primarily reflects the operations of the five participating fleets, with limited coverage in Scotland's island regions (Orkney, Shetland, Western Isles) and rural/off-grid sectors like farming and forestry. This highlights the need for further data collection efforts to obtain a more comprehensive picture of HGV activity throughout Scotland. However, despite these limitations, the data offers valuable insights into the minimum infrastructure required to facilitate a successful transition to sustainable HGVs in Scotland.

Findings:

Our agent-based model produced heatmaps of HGV refuelling and recharging locations popularity across Scotland. The heatmaps revealed:

BEVs: Heavy usage concentrated along major roads (A9, M74, A90) suggesting a need for public charging infrastructure in these corridors. Lighter usage in the central belt could be due to depot-based chargers for shorter-range HGVs.

HFVs: The Aberdeen-England route (A90, central belt, M74) emerged as a popular corridor, highlighting the potential need for strategically placed hydrogen refuelling stations.

The model estimated infrastructure size and capacity based on simultaneous refuelling/recharging events, including charging bays for BEVs, grid power requirements, and hydrogen supply for HFVs. This information aids in determining investment needs for Scotland's HGV decarbonization.

Encouragingly, stakeholders found the results representative and expressed willingness to provide additional data, fostering collaboration to refine the model and deliver more robust recommendations for sustainable HGV infrastructure development in Scotland.

Stakeholder discussions also identified application suitability for different vehicle types. HFVs were seen as more suitable for operations outside the electricity grid, like forestry, and for less frequent journeys to remote islands where establishing charging stations might not be economically feasible. This emphasizes the importance of a diversified approach using both BEVs and HFVs based on specific needs.

Value:

Our agent-based model is expected to serve as a planning tool that guides investment and phasing the development of future charging and refuelling facilities. The initial results of this project will be used to encourage more stakeholders to share data with us. Thus, the results obtained will be more representative for real-world HGV transportation in Scotland. Stakeholders can also analyse how future HGV operation should be reorganized, supposedly some of the proposed locations are infeasible. To our knowledge, efforts to plan infrastructure for future HGV operation by using empirical agent-based model that involve data from multiple stakeholders are currently lacking.

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Humanitarian Logistics

Unlocking Synergies: Exploring Coopetition in Surplus Food Redistribution Networks

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Purpose of this paper:

Food insecurity remains a pressing global concern, with the role of charitable surplus food redistributors becoming increasingly crucial (F. Facchini et al., 2023). These redistributors may be classified based on their size, as food aid wholesale distributors (FaWD) (e.g., FareShare, Company Shop) or food aid service organisations (FaSO) (e.g., food banks, schools, community cafés) (see Sawyerr et al., 2023). Previous studies (such as E. Facchini et al., 2018; Thapa et al., 2021) have, however, highlighted the numerous challenges in the supply chain that these redistributors operate in, with limited collaboration being a major highlight. They compete for both surplus food and funding.

Drawing inspiration from the benefits of coopetition observed in commercial food supply chains (Beckeman et al., 2013; Bouncken et al., 2015; Walley & Custance, 2010), this study explores the potential for coopetition among surplus food redistributors. Coopetition, a strategic concept that combines elements of cooperation and competition (Bengtsson & Raza-Ullah, 2016), has shown promise in enhancing supply chain performance by enabling the exploitation of synergistic effects of the paradoxical relationship (Bouncken et al., 2015; Raza-Ullah et al., 2014). In the context of surplus food redistribution (SFR), where issues of power inequalities, and resource and capacity limitations are prevalent (Sawyerr et al., 2023; Thapa et al., 2021), understanding the feasibility and implications of coopetition becomes critical. This study seeks to explore this to identify challenges and opportunities for coopetition in charitable surplus food redistribution.

Design/methodology/approach:

We interviewed managers from 19 FaSOs and 14 senior managers from 12 FaWDs in the UK, using a combination of expert and typical-case purposive sampling methods. We sought to capture interviewees' insights on collaboration and competition horizontally (between FaSOs and between FaWDs) and vertically (between FaSOs and FaWDs). We abductively analysed the collected data using NVivo R1 and an iterative engagement with the literature to identify challenges and opportunities for coopetition.

Findings:

FaSOs in similar geographical locations viewed each other as competitors for both funding and food and also viewed FaWDs operating in their regions as competitors for redistributable food. FaWDs viewed competition differently based on the size of their operations. Even though they also viewed each other as competitors, smaller regionally-based organisations viewed similar-sized organisations in other regions as collaborators. Primarily, competition in the food aid supply chain is for donations (financial and/or food).

Notwithstanding, we identified collaboration among redistributors. The most prevalent was FaSOs that deliver free or discounted food from FaWDs to disadvantaged consumers. As most FaWDs do not have consumer-facing outlets, they rely on FaSOs for the consumption of their redistributed food. Horizontally, FaSO collaboration was typically facilitated through city/town food partnerships. FaWDs operating in different geographic locations also collaborate by sharing specific highly donated surplus food they access from their regions.

These findings show there already exists a reasonable level of both vertical and horizontal coopetition among food redistributors. Notwithstanding, several major challenges hinder the full exploitation of the benefits of coopetition. Differences in organisational ethos and operational models result in conflicting priorities, and varying views on the type of consumers to support, and the type and duration of support to be delivered, among others.

Notwithstanding, there is a recognition of opportunities for joint fund applications, labour sourcing and use, exploitation of industrial expertise, acquisition and use of logistical resources, consolidated distribution and innovation. Considering power inequalities between redistributors and food donors (Papargyropoulou et al., 2022), organisations recognise the criticality of coopetition for negotiating the type, quantities and quality of donated surplus food as well as collection/delivery lead times.

Value:

Previous research has not explored coopetition in the context of surplus food redistribution. By examining current challenges and opportunities for its strategic utility in the food aid sector, this study can offer actionable insights for practitioners and policymakers alike. Ultimately, our findings contribute to the broader discourse on sustainable food systems and offer potential strategies for improving the efficiency and effectiveness of SFR efforts.

Research limitations/implications:

Some of the factors hindering coopetition among surplus food redistributors arise from donors, governments and other actors outside of the food aid supply chain. Future research can incorporate insights from these actors for a more holistic view of the challenges and opportunities.

Practical implications:

Our study draws upon a strategic concept that has been studied and applied within the food supply chain but is underexploited for SFR. Our findings crystallise the opportunities available to practitioners to pursue synergies for improved performance.

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Applications of Machine Learning Methods in Humanitarian Supply Chain – A Systematic Literature Review

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Purpose of this paper:

The objective of this paper is to examine the applications of machine learning (ML) in humanitarian supply chains (HSCs) while identifying key areas where ML can significantly enhance humanitarian operations. The study addresses a key gap in research concerning the application of ML in HSCs and proposes a theoretical framework focused on three observed dimensions: relief chain visibility, risk management, and planning.

Design/methodology/approach:

This study employs the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) to identify and classify key themes concerning the use of ML in HSCs. The authors identified and reviewed 105 peer-reviewed journal articles published since 2016, the year in which the first journal article on ML applications in humanitarian supply chains was published.

Findings:

The review reveals a notable expansion in ML applications in HSC research from 2020 onwards, demonstrating a growing interest and recognition of ML's capabilities to enhance HSC operations. Our analysis reveals several key insights and gaps that warrant further research. First, deep learning algorithms dominate the field, due to their capability to handle complex data in crisis situations, while ensemble methods are underutilized. Second, key application areas include humanitarian mapping and social media analysis, which emphasize situational awareness and rapid response in emergencies, contrasting with the operational efficiency focus in broader supply chain management. Third, there is a notable gap concerning the ethical implications of employing ML 'black boxes' given the importance of ethical considerations, such as privacy, bias, and equity, in ensuring responsible and transparent operations in humanitarian contexts. Forth, despite a strong focus on immediate disaster relief, there is a notable underrepresentation of ML applications in long-term development aid logistics.

Value:

This study introduces a novel framework that advances the theoretical understanding of ML's role in HSCs, highlighting how improved visibility and risk management can enhance operational relief planning.

Research limitations/implications:

This review identifies the potential of ML to significantly contribute to theory development in HSCs by introducing a structured framework focused on relief chain visibility, risk management, and planning but only based on a literature review.

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Supply Chain Skills, Training and Education

Configuring Aerospace Maintenance Operations for Future Demands: A Study of Singapore Airlines Engineering

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Purpose of this paper:

The aviation industry operates within a complex framework involving passenger, cargo, and freight operations. With demand for air transport set to double by 2040 at an estimated rate of 3.4% per annum globally (International Air Transport Association, 2023), there is need for more aircraft Maintenance, Repair, and Overhaul (MRO) services which is typically performed by the aerospace companies. In this context, our paper investigates the logistical operations and flows within the aerospace industry, with Singapore Airlines Engineering Company (SIAEC) an aircraft MRO company as the focal firm. Aerospace players such as SIAEC stay competitive through consistently reviewing its operations in the face of higher operating costs and supply chain disruptions which is impacting profitability (Chua, 2023).

The purpose of this paper is to analyse the state of operations and logistics in the aerospace maintenance industry in the Asia-Pacific, in the face of an uptick in travel demand and increased connectivity within Asia-Pacific, post Covid-19. The paper identifies issues by studying the industry's operational and logistical arrangements before applying continuous improvement approaches in areas such as automation, standardisation, and digitalisation. In so doing, SIAEC can better sense and overcome challenges, grasp new opportunities, remain resilient through reconfiguring resources, and build new capabilities dynamically to adapt to the dynamic landscape (da Costa *et al.*, 2020).

Design/methodology/approach:

A single-case (embedded) study is selected as appropriate for exploring the practices of aerospace companies in adapting to the changing environment post Covid-19. The selected case firm has begun a substantial realignment of its supply chain operations in response to the turbulent environment, which makes it a suitable case. The main instrument of data collection is semi-structured interviews with pertinent stakeholders in the firm to analyse the practices of the selected case firm based on three dimensions: sensing, seizing, and reconfiguring. Additionally, secondary research is conducted with relevant aerospace companies providing servicing and maintenance of aircrafts such as GE Aviation, AAR Corporation, and Hong Kong Aircraft Engineering Co Ltd. Doing so affords the necessary data triangulation to facilitate a reliable collection of information, necessary for comparing the similarities and differences of the challenges and processes. Supplementary data would also be gathered from local field visits, ground observations, and published documents.

Findings:

Preliminary analysis reveals several market and operational challenges. First, the sector is still old school as delivery notes - documents that specify a shipment's contents including the number of products, size, and weight are still tracked manually. However, the focal firm has realigned some of the operations to embrace automation and a digitalised process of scanning these notes onto a tracking system. Second, the joint warehousing between SIA EC and the sister company Singapore Airlines while beneficial can be improved as both use different storage systems to manage the logistics operations. In addition, the perennial delays and disruptions due to the poor visibility of trade and customs management practices is prompting the company whether or not to take control of the trade and customs management from freight vendors for better cost and operational savings. Third, the current practice of inventory management, procurement of spare parts, holding of customer's parts on consignment, and the escalation of the management of unserviceable spare parts to outsourced vendors based overseas require a reconfiguration of local maintenance capabilities. The net outcome of these current practices has resulted in longer lead times, which in turn lead to a longer grounding of an aircraft, leading to a loss of revenue to airlines as aircrafts are unable to fly (Badkook, 2016). The focal firm has sensed increasing market competition and opportunities in cargo, freight, and passenger traffic to overcome the market and operational challenges. Subsequently, seizing and configuring capabilities were employed to realise opportunities through stakeholder collaboration, process optimisation strategies, and investments in technology. However, resistance to change, lack of human capital, and workplace routines have become the major barriers in seizing and reconfiguring the sensed opportunities. Initial results also suggest that untapped reconfiguration capabilities such as new partnerships and technology could play an important role in responding to a changing environment. Based on the findings, the study intends to develop a suitable framework for SIA EC to remain competitive in the aerospace MRO sector.

Value:

The study adds to the ongoing discourse on improving and optimising aerospace engineering and maintenance practices. Specifically, the study provides a nuanced understanding of how continuous improvement approaches can remain relevant as a roadmap for exploring cutting-edge technologies, sustainable practices, and innovative strategies in the aerospace sector, with a view to building pertinent capabilities for competitive advantage.

Research limitations/implications:

This study contributes to the theoretical development of the continuous improvement technique of supply chain operations in the context of SIA EC and offers a perspective into how theory or management thinking can be operationalised in practice. As a single case research, the study poses obvious limitations in the generalizability of the findings across industry, time, and across geographies.

Practical implications:

This study highlights the value of embracing a continuous improvement mindset within the praxis of the post Covid-19 environment for aerospace companies and other firms across the Asia Pacific facing greater turbulence and uncertainty in the external environment.

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Reentrant Flow Shop Production Control with the Theory of Constraints for Wafer Fabrication Having Parallel Machines

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Purpose of this paper:

In a production line with capacity constraint resources (CCR) or bottleneck stations, the production control and the throughput rate are determined by the CCR station. In this study, we consider a production system with parallel machines and there are many rounds of reentrants during the production processes, and can be regarded as a reentrant flow shop process (RFS). In most RFS systems, the release of jobs is a push type without considering the WIP in each layer of reentrance. To resolve the excessive WIP in an RFS system, we consider the theory of constraints (TOC) and implement the DBR (drum, bottleneck and rope) to model RFS scheduling and to define appropriate buffer sizes at the CCR stations of diverse reentrant layers.

Design/methodology/approach STS:

We obtain production data of a type of semiconductor chip where the photolithography process is the most frequent reentrant. We designed nine scenarios based on the current RFS of the case company by applying the TOC and considering the time differences in parallel machines. A simulation model for the photolithography process was established using AutoMod simulation. Thirty simulation runs were performed for the mean and standard deviation. The goal is to identify the best scenario among the nine proposed ones.

Findings:

The simulation results demonstrated that Scenario 9, which involves dynamic buffers and assigning higher priority to products with more processing reentrance layers, achieved the highest throughput of finished products. The throughput of finished products in Scenario 9 is 22% higher than in the base scenario. It also shows improvements in maximum product stack-up and input-output ratio compared to the base scenario.

Value:

The paper studies dispatching rules for reentrant flow lines having parallel machines with data from the semiconductor industry, and this type of production system is common for producing a wide range of electronic devices. With limited buffer sizes on the shop floor, the number of WIPs is significant, especially for reentrant flow shops, to avoid being clogged with too many WIPs. Implementing DBR modeling from TOC, the nine scenarios demonstrate the effects of controlling buffer sizes on system performances.

Research limitations/implications:

The nine scenarios are designed based on the case company situations and may not be readily implemented in other industries. Moreover, the DBR modeling of the buffer sizes and CCR station schedule control should also be adjusted when employed in other applications.

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Integrating the Community of Inquiry Framework with Industry Insights for Enhanced Engineering Education for Sustainable Production Development

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Purpose of this paper:

This paper investigates the integration of the Community of Inquiry (CoI) framework into engineering education, with a particular focus on a master's course aimed at sustainable production development. The primary aim of the course is to enable students to link analytical, heuristic, and simulation-based methods with the practical needs and challenges of industrial fields in production and logistics [1]. The primary aim of this research is to study how embedding the CoI's three essential elements—social presence, cognitive presence, and teaching presence [2]—within the curriculum can transform the learning experience by linking theoretical concepts to practical industry applications. By integrating the CoI framework, this study aims to foster an educational environment where students develop practical and deep understandings of engineering problems, equipping them to address complex sustainability challenges.

Furthermore, the research explores the impact of combining traditional educational methods with direct insights from industry professionals through guest lectures, case studies, and real-world project collaborations. In this context, student projects that involve an industry partner provide a meaningful way for students to translate abstract knowledge into practice, and to develop the data management and communication skills desired in industry [3]. This integration is expected to bridge the often-cited gap between academic theory and practical application, offering students intellectually stimulating and practically relevant learning opportunities. The ultimate goal of this research is to propose and substantiate an educational model that adheres to academic goals while dynamically aligning with the evolving needs of the global engineering industry. This model aims to produce a generation of engineers who are not just theoretically informed but also practically adept, ready to contribute innovative solutions to the engineering field, particularly in tackling sustainability challenges.

Design/methodology/approach:

This study utilizes a qualitative research approach to evaluate the effectiveness of the CoI framework within an engineering educational context. By focusing on a master's level course dedicated to sustainable production development, the research incorporates a blend of theoretical teaching and practical industry exposure. The curriculum design includes comprehensive integration of industry insights through real-world case studies and guest lectures from industry practitioners, supplemented by collaborative projects that reflect current engineering challenges.

Data for this study was collected through various methods designed to ensure a thorough evaluation of educational outcomes. Observations of classroom dynamics provided insights into the interaction between students and the integrated teaching approach. Specific attention was given to a modelling and simulation group task, requiring students to create models and simulate processes to solve real problems from industrial cases. Feedback from industry partners was solicited to assess the relevance and practical applicability of the course content. Additionally, post-course surveys captured detailed student perceptions of their learning experiences, focusing on their engagement, motivation, and the applicability of their newly acquired knowledge. This multifaceted approach aims to provide a comprehensive dataset for evaluating the CoI framework's effectiveness when supplemented with industry insights.

Findings:

The integration of the CoI framework with robust industry input enhances the educational effectiveness of engineering courses focused on sustainability. The hands-on nature of learning activities and the relevance of industry insights increased student engagement and deepened their understanding of the material. Through modelling and simulation tasks, students applied theoretical knowledge in practical settings, enhancing their problem-solving skills and technical proficiency.

Interaction with industry professionals, including guest lectures and continuous communication with industry problem owners, provided invaluable insights into current trends, technologies, and challenges in the engineering sector. These experiences equipped students with essential competencies for the workforce, fostering professional readiness and adaptability. The curriculum's practical projects and case studies, developed in collaboration with industry partners, not only improved technical skills but also equipped students with innovative problem-solving abilities in sustainability-focused roles. This suggests that a curriculum integrated with the CoI framework and enriched with real-world industry insights effectively prepares students for successful careers in engineering.

Value:

This paper introduces a novel approach to engineering education by integrating the CoI framework with tangible industry insights, creating a robust educational model that enriches student learning experiences. The application of this model has demonstrated a profound impact on increasing student engagement and preparing them effectively for the professional engineering environment. The results of this research enrich the ongoing discourse on educational reform within the engineering field by advocating for a curriculum that is both academically rigorous and practically relevant, meeting contemporary industry demands.

By merging theoretical knowledge with real-world applications, the research showcases how experiential learning can effectively bridge the gap between academic environments and the operational realities of the engineering sector. This approach ensures that students are not just recipients of knowledge but active participants in their education, equipped with the necessary skills to succeed in their professional careers. The insights gleaned from this research are invaluable to educators, curriculum designers, and policymakers focused on enhancing the quality of engineering education, providing a clear framework for designing curricula that include both rigorous academic content and practical, industry-relevant learning opportunities. This dual focus is crucial for developing a generation of engineers ready to address future challenges with confidence and competence.

Research limitations/implications:

While the study provides compelling evidence for the benefits of integrating industry insights with the CoI framework, it is limited to a specific course and context. The non-mandatory nature of the post-course surveys could introduce a bias in the feedback collected, as only a subset of students chose to participate. Additionally, the relatively small number of students involved may limit the generalizability of the findings. Future research should explore the applicability of this approach across different engineering disciplines and educational settings to verify and possibly generalize these findings. Longitudinal studies are also needed to assess the long-term impact of this educational approach on students' career trajectories and their contributions to sustainable engineering practices.

Practical implications:

The findings of this study suggest that engineering curricula should incorporate more industry-relevant content to effectively bridge the gap between academic learning and professional practice. The course's integration of case studies, guest lectures, and practical projects, designed and developed in close collaboration with industry partners, not only enhances student engagement but also better prepares them for the challenges of the engineering profession, particularly in the realm of sustainability. Educators are encouraged to consider such integrations as a part of the curriculum, promoting a learning environment where students can continually apply theoretical knowledge in practical, real-world contexts. This approach not only enhances learning outcomes but also ensures that students are well-prepared for the practical challenges they will face in their careers.

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FULL PAPERS

Smart/digital connectivity in logistics and supply chains

A Conceptual Blockchain Framework of a Mixed Freight and Passenger Transportation Service in Rural Area

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Abstract
The paper focus on the problem between operators (the non-for-profit organizations, NPO) and multiple funding sources (e.g. government agencies and Corporate Social Responsibility (CSR) support) of a mixed passenger and freight in demand responsive transportation system (DRTS). This original system faces some reimbursement issue in rural area: (1) For operating units: write-off is slow. NPOs must wait one to two years to receive subsidies. The NPOs without fixed income, and wait a long time to receive subsidies. It is difficult to maintain system operations. (2) For public supporters (central/local government): It consumes administrative costs and manpower to repeatedly check whether the reimbursement documents are correct; (3) For private suppliers (CSR): it is difficult to grasp the usage status of resources and confirm resources is effectively used in real time. Thus, a conceptual blockchain (Etheren) framework is proposed to supervise and facilitate the overall system operations. This study tries to solve the problems between operating units and subsidy units through the upgrading and improvement of the existing mechanism (Etheren). The benefits are that funding sources and operator are members of the chain. Each unit on the blockchain can go to the node at any time to check the status of each transaction and cash flow. Make the information of each unit on the chain transparent and consistent, and improve the original need for manpower to check the payment data at various levels. Once it is found that the data has been tampered with or has errors, it needs to be returned, revised, and re-submitted, which takes a lot of time.

INTRODUCTION

The tribe locations are far away from the highway in Taiwan. The service of the highway bus carrier is focus on the main traffic arteries. Similarly, for freight operators, it takes a lot of travel time and cost to enter tribes or mountains for delivery. Feng et al (2023) address rural areas generally have smaller populations, making it challenging to establish public transport services as a commercial business. If the number of users decreases, services will inevitably be reduced or cancelled, and business sustainability becomes fragile.

In order to protect the justice for the local people of rural areas, the government try to help people's last /first mile of remote villages by subsides. A new type of shared transportation mechanism by local highway bus carrier, taxi, or township office. It’s called demand responsive transportation service (DRTS). (Vansteenwegen, P., et al. 2022)

The ecosystem of DRTS is operated by the non-for-profit organizations (NPOs), or non-governmental organizations (NGOs), and they cooperate with the fleet, or local private vehicles to jointly serve the transportation of the community. Besides, it has diverse resources from Ministry of Education, Ministry of Health and Welfare, Ministry of Transport, and private suppliers (CSR).

A mixed passenger and freight in demand responsive transportation system (DRTS). The freight service includes: collection of prescription drugs, consigning students’ luggage, sports equipment, water, donations, local farmer products, wheelchairs for passengers, and daily purchases for the company and/or individuals.

RESEARCH PROBLEM

The transport service with two mode service. One is passenger service, and the other one is freight transport service. The order of services is to carry passengers mainly and freight as a supplement. But, this original system faces some reimbursement issues in rural area: (1) For operating units: They can’t receive funds within a limit time. NPOs must wait one to two years to receive subsidies. The NPOs need to face that they have not enough money to cover expenses. It is difficult to maintain transportation service operations. (2) For public supporters (central/local government): It consumes administrative costs and manpower to repeatedly check whether the write-off documents are correct; (3) For private suppliers (CSR): it is difficult to grasp the usage status of resources and confirm resources is effectively used in real time. Thus, a conceptual blockchain framework is proposed to supervise and facilitate the overall system operations.

LITERATURE RESEARCH

Passenger and freight transport problem can be roughly divided into the following discussion aspects: It focus on optimizing and efficiency that analysis freight structure optimization and transport efficiency (like maximize the total freight time, optimizing time table, minimize the delay time of freight, maximize the total revenue). (Chen and Zhang, 2023, Li et al., 2022, Zeng and Qu 2022, Hörsting and Cleophas, 2023, Feng et al., 2023). Some paper investigates the policy of passenger and freight and analysis whether the model is sensitive to typical policy. (Schröder and Liedtke, 2017, Kiba-Janiak et al., 2021, Winkler and Mocanu, 2020, Cavallaro and Nocera, 2023) measures coordinated of passenger and freight aspect, policy and sustainable, matching. Some paper conducts the coordinate of passenger and freight and improve the regional coordination mechanisms. (Ding et al., 2022, Le Pira et al., 2021, Tiwari and Gulati, 2013) Tapia et al., 2023 address the crowdshipping is a new style of freight transport, but base on their investigate it will generate more CO2 emissions and total travel vehicle distance.

This study mainly discusses the optimization aspect. In view of the problems faced in practice, the study hopes to optimize information flow and cash flow to make operations, management and other aspects smoother.

Wang et al. (2018), Jhou et al., (2020) and Jhou et al, (2022) had mentioned this study perform in-depth research into the DRTS and is the first one to demonstration using local people as a service provider. Chu et al. (2022) had addressed this study developed multi-subsidy system under block-chain to solve payment delay problem. Wang & Zhang (2020) mentioned it used blockchain to integrated the demand and the driver through Roadside Unit (Roadside Receiver).

Nakamodo (2008) addressed using cryptography with a peer-to-peer (P2P) network structure, and through it, virtual currency transactions can be done in a peer-to-peer manner without the need for verification or guarantee by financial units (such as financial institutions) The concept of conducting transactions is called "decentralization". Vitalik Buterin address the concept of Ethereum for making this technology more flexible in 2014.

THE APPLICATION

The disadvantages of the original system are that 1) the operators receive the funds not immediately. Operators always face not enough money to cover expenses. 2) The use of subsidies is not transparent. It is difficult for subsidy units to know where their subsidies are being used. The study based on the empirical data collection and take Hualien as an example. In Hualien, Taiwan, it has transport service with passenger and freight. In this study, the blockchain (Etheren) play an important role in it. Because It has smart contract, it will be helpful for the execution phase of this study. This study tries to solve the problems between operating units and subsidy units through the upgrading and improvement of the existing mechanism (Etheren). This study separates three parts. First layer is input layer, after the transaction is completed, the transaction data will import it into the frontpage for waiting to be uploaded. Second layer is transmitted layer, it uses HTML and JSON to execute. After the transaction data about date, order number, fare is imported, the amount each funding sources has to pay will be automatically calculated. The third layer is execution layer, after the data is on-chain, the function of transfer will be triggered. It uses solidity of smart contract to complete it.

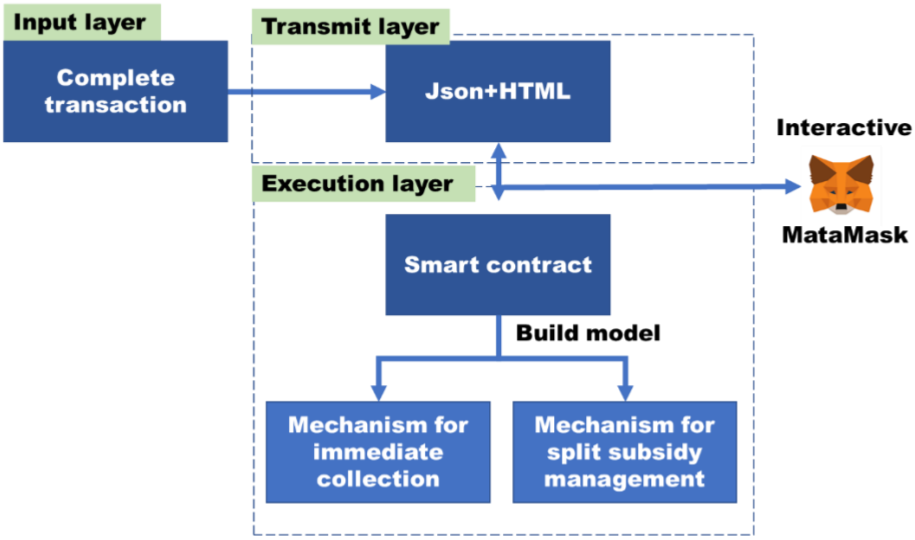

Figure 1 research structure

The benefits are that funding sources and operator are members of the chain. Each unit on the blockchain can go to the node at any time to check the status of each transaction and cash flow. Make the information of each unit on the chain transparent and consistent, and improve the original need for manpower to check the payment data at various levels. Once it is found that the data has been tampered with or has errors, it needs to be returned, revised, and re-submitted, which takes a lot of time.

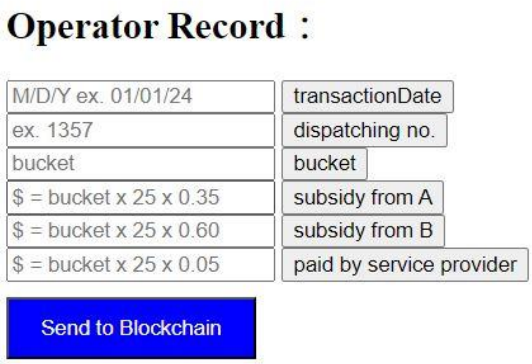

Figure 2 the concept of front interface

When the first-stage data is uploaded to the chain, smart contract will activate the second-stage transfer function, allowing the operator to start the remittance after the transaction is completed, or design conditions for activation, such as within a certain period or after accumulating several transaction data. The mechanism allows the operator to receive funds immediately or within a limited time. This study sets the transfer immediately after the transaction is completed.

The system is different from existing ones because it allows operating units (NPOs) to collect accounts receivable through the design of timely transfer after transactions, avoiding the delay in the timeliness of payment due to the check of payment documents at various checkpoints, and turning into uncollected accounts receivable. Over time, it may cause a burden on the business operators and reduce their willingness to continue investing.

THE RESULT AND SUGGESTION

The characteristics of the blockchain (data transparency, distributed data storage, data is not easily tampered with) can create an environment of real-time collection, information transparency, and a trustworthy environment with the smart contract function of Ethereum. It can solve the current practical problems in Taiwan's mixed passenger and

freight DRTS; in terms of research, innovative technological solutions are proposed for the better management of limited funding resources.
Utilizing the characteristics of the blockchain (data transparency, distributed data storage, and data not easily tampered with) can create an environment where information is transparent and trustworthy. In addition, the smart contracts of Ethereum can design settlements with different suppliers. The management mechanism and the operator's real-time bill collection function can effectively solve the existing problem of a mixed passenger and freight DRTS in Taiwan.
Through the introduction of innovative blockchain technology, operators can provide a more sustainable mixed passenger and freight transportation service; for those multiple funding providers, the split management mechanism can be effective by grasping subsidy information, so as to determine the usage status of resources and confirm whether resources are being used effectively or not.

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Exploring Acceptance of Industry 4.0 Adoption in Supply Chain in Emerging Economies

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Introduction

Modern technology advancements are becoming more and more prominent as a result of the complex and dynamic corporate environment, consumer demands, and the requirement for organizations to be flexible and adaptable, these drastic changes have triggered the 4th industrial revolution in most if not all of the companies are currently interested in Industry 4.0 (Fatorchian and Kazemi, 2019). Industry 4.0 (I4.0) implementation is a difficult task that will probably take ten years or longer to complete, while the adoption of this new manufacturing process is a multifaceted process that will inevitably encounter a wide range of obstacles and difficulties, including social, political, technological, and scientific ones (Mohamed, 2018). In order to construct I4.0 infrastructure, organizations must invest an enormous amount of capital, the risk associated with emerging technology is higher because of the possibility of monetary losses and unrealized return on investment (Senna et al., 2022). Moreover, there's an insufficient amount of qualified workforce that can deal with I4.0 technologies, it is essential to have a diversified workforce with highly developed skills (Dalmarco and Barros, 2018).

I4.0 is expected to have a substantial impact on all key components of supply chain (SC) processes creating a modern SC, thus boosting the overall performance and efficiency (Abdirad and Krishnan, 2020). Till now there is a lack of clear understanding on how to properly implement I4.0 as it has not been widely used yet (Tahajoni et al., 2017). There have been few studies that investigates the readiness of I4.0 and also the factors affecting and delaying its implementation in emerging economies, both did not receive much of an attention (Khourshed et al.,2023). Accordingly, this paper aims to determine the factors that affects the acceptance of I4.0 in SC in emerging economies focusing on Egypt through the technology acceptance model (TAM).

Literature Review

While there are many advantages that I4.0 brings on, there are several key challenges and difficulties that lie ahead to be considered (Xu et al.,2018). Supply chain management (SCM) involves integrating processes, organizations, and resources to achieve the seamless flow of products, services, and information (Lambert and Enz, 2016). SC performance is influenced by various factors, including the structure of the SC, inventory control policy, information sharing, customer demand, forecasting method, lead time, and review period length with information sharing as a critical driver, connecting various partners and enabling coordinated activities throughout the SC (George and Pillai, 2019). Information flow and quality are recognized as essential elements in SCM practices and the coordination of activities (Ramayah and Omar, 2010).

I4.0 is expected to radically change how SC are operating or designed, so that SC in the era of I4.0 will be developed to a new stage in which the coordination of materials, information and financial flows in corporate networks is largely automated and permeated with digital technologies (Hofmann et al., 2019). The opportunities surrounding the rapid digitization of I4.0 is trending in SCM, these opportunities have allowed SC to access, store and process a large amount of data both from within a firm and externally, which allows firms to obtain individualized customer data to personalize the sales process, product design and service (Sassi et al., 2021). Numerous adoption models can be used to analyse the variables that influence user's decision making, including the technology adoption model (TAM), theory of planned behaviour (TPB), unified theory of acceptance and use behaviour (UTAUT), theory of reasoned action (TRA), and innovation and diffusion theory (IDT) (Jain et al., 2023).

In 1989, TAM was introduced as a mean to gain insight into individual behaviours regarding the acceptance and adoption of information technology (IT) (Kamble et al.,2019). TAM was

initially focusing on two key constructs, perceived usefulness (PU) and perceived ease of use (PEOU) and has emerged as the predominant model for forecasting technology use (Kamble et al., 2019; Queiroz and Wamba, 2019).
According to Davis (1989), PEOU refers to the extent to which an individual believes that using a new system or technology requires minimal effort. While, PU is defined as the subjective belief of potential users that utilizing a system or its application will enhance their job performance within the organizational context (Lee et al., 2003).
Afterwards, Shih (2004) introduced a model that integrated trust into the TAM, demonstrating that trust a superior comprehension of consumers' behavioral intention compared to other established models. According to Lin (2011), trust plays a crucial role in minimizing uncertainty and risks while fostering a feeling of security. Recognizing the significance of trust in risk reduction and promoting the adoption and usage of technology, Gao and Bai (2014) incorporated trust into the TAM and put forth a positive association between trust and the behavioral intention to utilize I4.0 technologies. Furthermore, in the assessment of technological innovations, it is crucial not to overlook the social context within which decision makers operate (Venkatesh et al., 2012; Hsu and Lu, 2004; Venkatesh et al., 2003).

Research Problem
I4.0 is expected to have a substantial impact on all key components of SC processes creating a modern SC, thus boosting the overall business productivity (Abdirad and Krishnan, 2020). Till now there is a lack of clear understanding on how to correctly implement I4.0 as it has not been widely used yet (Tahajoni et al., 2017). There have been very few studies that investigates the readiness of I4.0 and also the factors affecting and delaying its implementation in emerging economies, both did not receive much of an attention (Khourshed et al.,2023). Accordingly, this study aims to determine the factors that affects the acceptance of I4.0 in SC in emerging economies through utilizing TAM, with figure 1 presenting the conceptual research framework of this paper followed by the research hypotheses.

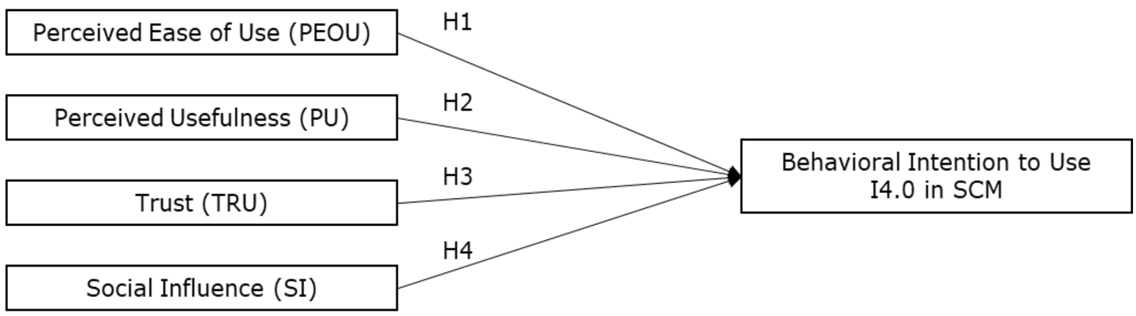

Figure 1: Conceptual framework of this study

H1: Perceived ease of use has positive impact on the behavioral intention to use I4.0 in SCM.
H2: Perceived usefulness has positive impact on the behavioral intention to use I4.0 in SCM. H2: Trust has positive impact on the behavioral intention to use I4.0 in SCM.
H4: Social Influence has positive impact on the behavioral intention to use I4.0 in SCM.

Research Methodology
As this paper is investigating the level of acceptance of I4.0 in SC, this paper is descriptive research study through quantitative research method. The quantitative research method is employed to measure behaviors, knowledge, opinions, or attitudes precisely. Surveys are used as a method of data collection. A survey is a form of quantitative research, employs a highly structured interview process to collect information. The comprehensive aim of a survey is to uncover similarities and differences by obtaining comparable data from distinct subsets within the chosen sample. The versatility of surveys is significant, allowing for the extraction of a wide range of abstract information through the act of questioning others. The data collected from the survey is considered the most reliable in

this case allowing results to be consistent and provides a faster response than other methods.
The survey developed for this research paper was based on validated items from previous literature. The survey was made of five main constructs which are perceived ease of use (PEUO), perceived usefulness (PU), trust (T), social influence (SI) and behavioural intention to use (BI), description of constructs and items included in each construct is presented in table 1. All items were tested by Likert scale questions on a scale from one to five, where one is "strongly disagree" and five is "strongly agree".

Construct	Measurement item	Source
Perceived ease of use (PEOU)	The use of industry 4.0 will reduce the work effort in the organization.	Venkatesh and Davis, 2000
	The degree of the technical competence of the personnel for the use of Industry 4.0 in the organization facilitates its implementation.	
	My interaction with industry 4.0 will be clear and understandable.	
Perceived usefulness (PU)	Industry 4.0 will improve my job performance in the organization.	Cordero et al.,2023
	Industry 4.0 based organization will improve its performance.	
	Investment returns are expected based on the use of Industry 4.0.	
Trust (TRU)	Industry 4.0 technologies are trustworthy.	Kumar et al., 2018; Gao and Bai, 2014
	Industry 4.0 technologies provide reliable information.	
	Industry 4.0 technologies can be used on the long run.	
Social Influence (SI)	People who are important to me would recommend using Industry 4.0 technologies.	Gao and Bai, 2014; Venkatesh et al., 2003
	People who are important to me would find using Industry 4.0 technologies beneficial	
	The senior management of this business has been helpful in the use of Industry 4.0.	
	In general, the organization has supported the use of Industry 4.0.	
Behavioral Intention to use I4.0 (BI)	Assuming I have access to Industry 4.0, I intend to use it.	Arnold et al.,2018; Sila,2018; Venkatesh and Davis, 2000
	Given that I have access to Industry 4.0, I predict that I would use it.	
	I plan to use Industry 4.0 in the next months.	
	Our top management is willing to take risks involved in the adoption of Industry 4.0.	

Table 1: Items for survey development

SC professionals/managers in organizations operating in Egypt were the intended population in this paper, while the unit of analysis is each individual of them representing their own opinion or perspective regarding the acceptance of I4.0 adoption in SC. Convenience non-probability sampling was adopted due to its cost-effectiveness and time efficiency.
Since the information and communication technology (ICT) sector in Egypt is emerging with a growth rate higher than Egypt's overall GDP growth level, and the Egyptian government is taking a series of investments and infrastructure updates to support its ICT

2030 strategy and accelerating the digital transformation plan of Egypt (Egypt - Information and Communications Technology and Digital Economy, 2021).
The expected sample size was designed to be 60 respondents. Yet, due to time and accessibility limitations, the final sample was composed of 50 SC managers. The sample was composed of different SC professionals from different SC processes such as logistics, procurement and production with varying years of experience from 5 years to more than 7 years.
The data collection for this study included responses from a diverse range of industries, with the majority coming from Fast Moving Consumer Goods (FMCG) sector and Food and Beverages sectors, followed by e-commerce and logistics companies.
The survey asked participants about I4.0 in general without referring to specific technologies within I4.0. Although this might seem broad, but recognizing that Industry 4.0 is still in its nascent stage and may be relatively unfamiliar to respondents, this survey deliberately refrained from focusing on specific I4.0 technologies, thereby fostering a more inclusive and comprehensive assessment of the phenomenon.
In this paper, the quantitative analysis was carried out using IBM SPSS (Statistical Package for Social Sciences) Statistics 19 software. Before engaging with these statistical tests, it is essential to assess the validity and reliability. Nevertheless, as all survey items were adopted from established surveys in previous articles, the evaluation of validity was omitted. In terms of research reliability, the evaluation involved interitem consistency reliability through Cronbach's alpha (ɑ), that gauges the extent to which items in a set are correlated. Reliability testing was conducting for the first 15 respondents as pilot testing, results confirmed the surpass the acceptable range of 0.7 except for two constructs – PEOU and PU- yet results were overlooked due to small sample size suggesting further investigation of reliability for total sample.
Statistical Analysis was carried out to validate the connection among variables, involving correlation analysis through the creation of a correlation matrix, utilizing a Pearson correlation coefficient. To evaluate the significance of relationships within the developed conceptual framework presented in figure 1, multiple regression analysis was employed incorporating more than one independent variable and one dependent variable. Finally, the results of multiple regression analysis are used to formulate a regression equation that maximally predicts the dependent variable.

Results and Analysis

Regarding the reliability testing, as shown in table 2 the all-items Cronbach’s alpha for each construct after finalizing the data collection (n=50) is greater than 0.7 which is equivalent to good and highly reliable data.

Items	Number of Items	Cronbach’s Alpha value N=15	Cronbach’s Alpha value N=50	Decision
All items	17	0.927	0.900	Good
PEOU	3	<u>0.616</u>	0.702	Acceptable
PU	3	<u>0.516</u>	0.766	Acceptable
TRU	3	0.851	0.793	Acceptable
SI	4	0.805	0.799	Acceptable
BI	4	0.736	0.756	Acceptable

Table 2: Cronbach’s alpha reliability coefficient at n=15 (pilot testing) and n=50

The Pearson Correlation Coefficient was utilized to examine the relationship between the following; independent variables; PEOU, PU, TRU, and SI and the dependent variable BI, and results are presented in table 3. It was found that there is a strong positive correlation between PEOU (r=0.711), PU (r=0.702) and BI. While there is a moderate positive correlation between SI (r=0.614) and BI. Yet there was no significant relationship between TRU and BI. Hence, this leads to the rejection of H3, as the correlation should be there as a prerequisite for the regression analysis.

		PEOU	PU	TRU	SI
BI	Pearson Correlation	.711**	.702**	.378**	.614**
	Sig. (2-tailed)	.000	.000	.007	.000

** Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations using Pearson correlation coefficient (n=50)

Accordingly, a multiple regression analysis test was implemented to measure the extent to which variations in BI can be accounted for by PEOU, PU and SI, multiple regressions results including model summary, ANOVA, and coefficients are presented in table 5, table 6, and table 7 respectively.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.786[a]	**.618**	.584	.29788	2.256

a. Predictors: (Constant), SI, TRU, PU, PEOU

Table 4: Multiple Regression – Model Summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.468	4	1.617	18.225	**.000[a]**
	Residual	3.993	45	.089		
	Total	10.461	49			

a. Predictors: (Constant), SI, TRU, PU, PEOU

Table 5: Multiple Regression – ANOVA

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.345	.484		.713	.480		
	PEOU	**.499**	.164	.439	3.046	.004	.408	**2.449**
	PU	.398	.138	.373	2.887	.006	.508	**1.970**
	SI	.154	.150	.152	1.027	**.310**	.386	**2.591**

Table 6: Multiple Regression – Coefficients

To confirm the non-existence of multi-collinearity, VIF should be less than 10 (Gignac, 2019). Results showed that all VIF values are less than 10, which confirm that there are no multi-collinearity problems across the independent variables.

The overall explanatory power of the model is reflected in the R -square value of 0.618, which indicates that about 61.8% of the variance in BI is due to the combined effects of PEOU, PU and SI, with p-value less than 0.001 indicates that the regression model is statistically significant. Accordingly, the unstandardized regression equation based on these results can be expressed as follows:

Equation 1: BI = 0.345 + 0.499*PEOU + 0.398*PU + 0.154*SI

Intriguingly, SI does not produce a statistically significant effect on BI, as indicated by its non-significant coefficient (p = 0.310). This highlights the important role of PEOU and PU in shaping users' behavioral intentions, while the influence of social factors, as captured by SI can be neglected. Hence, Stepwise regression analysis was then conducted to verify which independent variables had the greatest impact. As stepwise regression enables the analytical program to identify variables that may be omitted but have no effect on the overall regression model, it can also be used to determine which variables are most important to include (Pallant, 2011). Results of stepwise multiple regression analysis including model summary, ANOVA, and coefficients are presented in table 7, table 8, and table 9 respectively.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.711[a]	.506	.496	.32809	
2	.778[b]	**.605**	.588	.29650	2.329

a. Predictors: (Constant), PEOU, b. Predictors: (Constant), PEOU, PU

Table 7: Multiple Regression using Stepwise method – Model Summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.294	1	5.294	49.184	**.000[a]**
	Residual	5.167	48	.108		
	Total	10.461	49			
2	Regression	6.329	2	3.165	35.999	**.000[b]**
	Residual	4.132	47	.088		
	Total	10.461	49			

a. Predictors: (Constant), PEOU, b. Predictors: (Constant), PEOU, PU

Table 8: Multiple Regression using Stepwise method – ANOVA

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.703	.466		1.509	.138	1.000	**1.000**
	PEOU	.809	.115	.711	7.013	.000		
2	(Constant)	.191	.447		.427	.671	.577	**1.733**
	PEOU	.503	.137	**.442**	3.663	**.001**	.577	**1.733**
	PU	.442	.129	**.414**	3.431	**.001**	1.000	**1.000**

Table 9: Multiple Regression using Stepwise method – Coefficients

Results showed that only PEOU can be considered as a predictor for BI, as in model 1, The results show that this model has a strong explanatory power, with an R-square of 0.506, indicating that about 50.6% of the variance in BI can be explained by PEOU alone. Building on model 1, model 2 introduces PU as an additional predictor. The extended model exhibits a high R-square value of 0.605, indicating improved explanatory power. Both PEOU and PU are found to be significant predictors (p=0.000) for BI. The unstandardized regression equation for these results, can be shown as follows:

Equation 2: BI = 0.191 + 0.503*PEOU + 0.442*PU

These findings are consistent with the first regression results, reinforcing the importance of perceived ease of use and perceived ease of use in forming users' behavioral intentions Furthermore, the stepwise approach lends support to the exclusion of social influence as an important predictor in this particular case. Thus, these results provide evidence to support H1, H2, and H4.

Discussion

Consistent with the previous literature, the first hypothesis suggesting that perceived ease of use has a positive effect on the BI to use I4.0 in SC was supported. Such finding is consistent with original TAM, emphasizing the important role of easy-to-use applications in conceptualization of users to adopt new technologies is emphasized (Davis, 1989; Lee et al., 2003). Clearly, the intuitive usability of technology is recognized as a critical determinant in users' acceptance patterns.

Similarly, the second hypothesis suggesting that perceived usefulness, positively influence the BI to use I4.0 in SC is also supported. The results, again, are consistent with the established literature, particularly the TAM, which emphasizes the importance of perceived usefulness in predicting technology adoption (Davis, 1993). This finding is further supported by previous research highlighting perceived usefulness as a fundamental driver of users' behavioural attitudes toward technology (Lee et al., 2003; Chatterjee et al., 2021).

In contrast, the third hypothesis suggesting that trust has a positive effect the BI to use I4.0 in SC. However, results based on correlation analysis, interpreted that trust and behavioural intention to use I4.0 in SC are not correlated nor statistically significant. Thus, hypothesis 3 was rejected. This contradicts with some existing literature that emphasizes the role of trust in technology adoption (Shih, 2004; Gao and Bai, 2014). This unexpected result suggests that the relationship between trust and I4.0 acceptance may be more complex, thus further research is needed.

Finally, fourth hypothesis suggesting that social influence has a positive effect on BI to use I4.0 in SC, initial regression results supported this hypothesis, and are consistent with theoretical frameworks such as the theory of reasoned action and existing research in the field of information systems (Venkatesh et al., 2012; Hsu and Lu, 2004). However, further analysis for significance of trust as a predictor for BI to use I4.0 in SC revealed that trust is not a significant predictor that can be overlooked.

In summary, findings of this research are consistent with the theoretical assumptions of TAM, regarding the vital role of perceived ease of use and perceived usefulness on the behavioural intention to use I4.0 in SC. Furthermore, findings present a compelling paradox regarding the significance role of trust and social influence, as conventional literature posits both variables as significant predictors, this paper results suggest a minor role of trust and a non-significant impact of social influence on the behavioural intention to use I4.0 in SC.

Conclusion and Future Recommendation

This paper aimed to investigate the acceptance to implement I4.0 in SC in emerging economies with Egypt as a sample of an emerging economy, by assessing the factors for acceptance for such revolutionary technologies as suggested by TAM. The research was based on a descriptive research design, aiming to provide a comprehensive description of the research problem. Quantitative research was employed, involving the gathering of data for statistical analysis to accurately quantify information. Surveys served as the method of data collection, collecting data from 50 SC managers.

Findings align with previous research regarding the acceptance of I4.0 technologies. The results validate some of the previously adopted models in other articles, such as perceived ease of use, perceived usefulness. However, findings also invalidated the relationships between other variables such as trust and social influence and the behavioral intention to use or accept I4.0 in SC.

To sum up the research implications, the theoretical implications of this paper highlight the strengths derived from the utilization of primary data collected through online surveys and the exploration of a nascent field. In practical terms, organizations aiming to enhance the adoption of I4.0 in SC should invest in intuitive interfaces, comprehensive training programs, and continuous support mechanisms to address concerns related to ease of use and perceived usefulness, while initiating campaigns for social awareness to increase the impact of the social influence.

One of the main limitations faced is the challenge of reaching a substantial number of SC managers within a constrained time frame to complete the survey. Furthermore, the use of TAM to study technology adoption by individuals rather than by organizations might be considered as limitation for this research findings, recommending future research to use other models -such as technology, organization, environment (TOE) framework- to analyze the organizations' perspective on I4.0 adoption.

Furthermore, the rejection of the trust concept suggests a deepening of the mechanisms by which trust operates in the adoption process, future research could delve into specific aspects of trust that are most important to Industry 4.0 technologies. Finally, one more variable that this paper did not take into consideration regarding the acceptance factors, is the cultural factors. Understanding how cultural factors affect technology adoption in SC in different or specific culture context, adds richness to the theoretical landscape, and opens the way for more targeted research on the interactions between different cultural dimensions and between I4.0 adoption.

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Blockchain Enabled Demand Information Sharing to Mitigate the Bullwhip Effect: An Agent-Based Modeling and Simulation

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INTRODUCTION

Since the mid-90s, supply chain management (SCM) has risen in significance in both academia and industry. A supply chain (SC) is comprised of various organizations striving to provide the highest level of customer service at the lowest costs (Chopra et al. 2016). The traditional supply chain (TSC) typically operates in a sequential manner where each echelon works independently. These leads to challenges such as lack of coordination, sharing distorted demand information, uncertainty, and duplicated demand forecasting, emphasizing the individual optimization.

Interorganizational sales and operations planning within the SC presents unique challenges stemming from the disparate nature of multiple organizations involved. Coordination among these entities is often hindered by communication barriers, incompatible systems, and disjointed decision-making processes (Smith et al. 2018). Additionally, the sharing of demand information is often distorted due to data discrepancies and limited visibility into upstream and downstream activities (Brown and Jones, 2019). Uncertainty in demand forecasting is further exacerbated by conflicting forecasts and a lack of synchronization between partner organizations (Gupta and Sharma, 2017). Consequently, individual optimization within each organization may lead to suboptimal outcomes for the entire SC. The bullwhip effect (BWE) is a well-known inefficient consequence of such challenges in which small fluctuations in customer demand result in larger variations in orders placed further up the SC. Excessive inventory levels, poor customer service, challenges in production planning and scheduling, increased costs in production, transportation, and inventory carrying are some of the negative consequences caused by the BWE. The BWE can be attributed to four operational causes (Lee et al., 1997): demand signal processing, rationing game, order batching, and price fluctuations.

Information sharing (IS) is a critical element in mitigating the challenges of the BWE and driving improvements in interorganizational planning. Effective IS facilitates alignment between sales forecasts, production plans, and inventory levels across multiple organizations in the SC (Cao and Zhang, 2011). By providing accurate and timely demand information, IS reduces the BWE and enhances collaboration and trust among SC partners. It enables proactive identification and resolution of SC disruptions, thereby improving overall efficiency and resilience. Researchers have come up with several ways to overcome the BWE, including SC contracts (Pagnozzi and Saral, 2021), joint decision making (Gualandris et al. 2021), and IS (Wang et al. 2021; Ma et al. 2021). Apparently, IS was found to be the most significant coordination mechanism to mitigate the BWE (Wang and Disney, 2016). Additionally, the advancement of information technology (IT) is crucial to facilitate inter-organizational coordination among SC echelons to remain competitive in the marketplace (Sahay and Ranjan 2008).

Disruptive technologies such as artificial intelligence (AI), Internet of Things (IoT), big data, and blockchain are the main technologies that are reforming Industry 4.0. Recently, blockchain technology (BCT) gained intensive attention after the new peer-to-peer financial trading system of the cryptocurrency, Bitcoin. Furthermore, BCT has the potential to be a remedy for trust and visibility issues among SC echelons due to several inherited features such as decentralization, data validation, immutability, and transparent IS (Omar et al. 2021). Therefore, BCT is considered as a source reality, truth, and real-time information detection (Xu et al. 2019).

The bullwhip effect (BWE) is a critical issue in supply chain management (SCM), where order variability increases as one moves upstream in the supply chain. Strategies to mitigate BWE include information sharing and improved demand forecasting (Sterman, 1989; Jeong & Hong, 2019). However, the integration of blockchain technology (BCT) into SCM presents a novel approach to addressing this issue by enhancing transparency and information flow. Recent research (Hyperledger, 2022) has highlighted the potential of permissioned blockchains to manage orders and share customer demand information (CDI) securely. Despite these advances, the specific impact of BCT on mitigating the BWE remains underexplored. Therefore, this research aims to fill this gap by investigating how BCT can improve customer demand information (CDI) sharing and thereby reduce the BWE with respect to IS structure and coordinated operations planning by implementing agent-based modelling (ABM). The key research questions are:

1. How does BCT affect order variability in a supply chain?
2. What mechanisms enable BCT to enhance information visibility and reduce the BWE?

In the following, a brief literature review on ABM in SCM and blockchain in SCM is introduced. Then, the research design with the proposed agent-based simulation model is presented. Following this, the simulation results are analysed. Finally, the paper concludes with a discussion of implications and further research.

LITERATURE REVIEW

Agent-based modelling and SCM

ABM is an intelligent approach employed to simulate and investigate complex systems by modelling individual interactions within a given environment (Tang and Pan 2014; Pour et al. 2018). An agent represents an autonomous entity capable of making decisions and interacting with multiple entities based on predetermined behaviours (North and Macal 2007). ABM has been used in different SC areas, such as inventory management, procurement, scheduling, and production (Tang and Pan 2014). Moreover, ABM provides a bottom-up approach, allowing for the examination of how individual interactions impact system behaviour (Gilbert, 2008). Several papers use ABM to address a range of challenges within SCM. Particularly, Fu and Xing (2021) proposed a model combining an evolutionary algorithm and ABM to resolve resource conflicts in a project-driven SC under decentralized decision-making and information asymmetry. Li et al. (2002) employed ABM to simulate the information-sharing correlation between a buyer and a seller. The results show that IS increases order fulfilment rates and reduces order cycle time and demand uncertainty. Moreover, Zhu (2008) used ABM to study the impact of horizontal and vertical IS among customers and among suppliers.

Blockchain technology and SCM

BCT is a distributed and decentralized database that securely stores and transfers data through blocks that are chained together with cryptographic technology (Zachariadis et al. 2019). The transactions are recorded in the blocks after being validated by the network nodes through a consensus algorithm. The main idea of BCT is allowing the nodes to transact information in a peer-to-peer network that stores the information in a distributed manner (Ølnes et al. 2017). BCT consists of three main technologies: consensus algorithms, smart contracts, and cryptography. Consensus algorithms such as proof of work (POW) and proof of stake (POS) are responsible for transaction validity and ownership proof of all nodes (Feng et al. 2020). Smart contracts are self-executing contracts written in codes that are responsible for transaction execution (Tanwar et al. 2020). Cryptography is important for creating encrypted public keys and hash functions (Wang et al. 2019), which convert incoming data into a compact output of fixed length and support consistency, authenticity, and unchangeable nature of the distributed data ledger. Several research studies have investigated the implementation of BCT in the SC field. Pishdad-Bozorgi et al. (2020) examined how BCT fosters a trust-enhanced environment within the construction

SC. They emphasize the distributed trust capabilities of BCT, which promise substantial benefits to the sector. Pour et al. (2018) examined the application of BCT in governing sand supply. Longo et al. (2019) demonstrate that adopting BCT technology to share accurate information with suppliers can result in significant economic and operational benefits while minimizing the negative consequences of information asymmetry.

RESEARCH DESIGN

In our research, we use ABM to investigate the impact of demand IS via BCT on the mitigation of the BWE for several reasons. Firstly, ABM allows us to model the complex interactions between different entities in the SC, such as customers, retailers, wholesalers, producers, and suppliers, which is essential for capturing the dynamics of IS across multiple echelons. Additionally, ABM is well-suited for representing heterogeneity among SC echelons, as mentioned in our model, where factors like safety stock, delivery lead time, and smoothing factor vary. Moreover, ABM enables the simulation of dynamic behaviours over time, which is crucial for understanding how changes in IS practices affect the BWE under different scenarios. In this paper, two IS scenarios are considered: (i) no IS (NIS) (ii) customer demand IS via BCT (CDIS-BCT). The purpose of BCT adoption is to redesign the process of sharing information as a new remedy to mitigate the BWE effect and enhance trust and visibility related issues among SC echelons.

Blockchain technology (BCT) is integrated into the agent-based simulation to address trust and visibility issues in the supply chain. In the CDIS-BCT scenario, BCT is used to ensure secure, immutable, and transparent sharing of customer demand information (CDI) across all supply chain echelons. Each transaction or update in CDI is recorded on a permissioned blockchain, providing a decentralized ledger accessible to all authorized SC participants. This ledger ensures that all participants have access to the same real-time data, reducing the risk of information distortion and enhancing coordination among the echelons. By providing a single source of truth, BCT helps mitigate the bullwhip effect by enabling more accurate demand forecasts and inventory management decisions.

The BCT mechanism operates as follows:

1. Data Validation: Every update in customer demand information is validated through consensus protocols before being added to the blockchain.
2. Immutability: Once recorded, data cannot be altered or deleted, ensuring the integrity of information.
3. Transparency: All authorized supply chain participants can view the recorded data, fostering trust and collaboration.
4. Decentralization: Unlike traditional centralized databases, the blockchain operates on a decentralized network, reducing the risk of single points of failure and enhancing the resilience of information sharing.

The BWE is the main performance metric that is calculated by the order variance ratio (OVR) which represents the variance of orders placed by echelon to its provider divided by the variance of echelon i customer demand. To perform the mathematical modelling, we adopted the assumptions that have been used in the literature (Sterman 1989; Jeong and Hong 2019).

The simulation parameters were carefully set based on industry standards and previous literature (Jeong and Hong, 2019; Shaban et al., 2020). Key parameters include the initial demand forecast, order-up-to levels, and lead times, which were calibrated to reflect realistic supply chain conditions. Table 1 details the specific parameter values used in the simulation. The robustness of the results was ensured by running multiple iterations and conducting sensitivity analyses to account for variability in key parameters.

In this model, we considered a serial SC structure consisting of a customer (i = 0), a retailer (i = 1), a wholesaler (i = 2), a producer (i = 3) and a supplier (i = 4). For

investigating the BWE mitigation, the model assumes a single product which is commonly used in SC analysis. The customer demand is normally distributed. The SC echelons use an order-up-to policy to manage their inventory. Exponential smoothing is used by all SC echelons for demand forecasting. Heterogeneity is considered for all echelons with different safety stock factor (ε), delivery lead time (Ld) and smoothing factor (α). The unfulfilled orders at any echelon are not lost but they become backlogs. Finally, the SC echelons have unconstrained capacity, while a nonnegative condition for order quantity is assumed, i.e., the products delivered to downstream echelons can't be returned to the supplier.
Following the SC model presented in (Sterman 1989; Chatfield et al. 2004), each echelon i in any period t receives shipment (SR_t^i) from one step upstream echelon $(i+1)$ which is calculated as the minimum value of demand considering the backlogs and the on-hand inventory after upstream delivery of the product as shown in Eq. (1). Then, echelon i fulfils the incoming orders from its on-hand-inventory (I_t^i) which is calculated by adding the initial on-hand inventory to the orders quantity that is released from upstream echelon, $(SR_{t-Ld_i}^{i+1})$, and subtracts the orders quantity that is delivered to downstream echelon, (SR_t^i), shown in Eq. (2). The unfulfilled order is backlogged (B_t^i) which is presented as the initial backlog plus the orders or demand form downstream echelon (O_t^i) and the shipment received from upstream echelon (SR_t^i) as in Eq. (3). After that, the echelon i update its work-in-progress inventory (WiP_t^i) which is calculated by the initial work-in-progress plus the shipments sent by upstream echelon at time t (SR_t^{i+1}) minus the shipments sent by upstream echelon ($SR_{t-Ld_i}^{i+1}$) at time $t-Ld$, as shown in Eq. (4). Then, echelon i forecast the demand ($\widehat{D}_t^i$) in which the demand received by retailer ($i=1$) in period t is the actual customer demand (D_t) as shown in Eq. (5). However, the demand received by upstream echelons ($i>1$) is the order quantity placed one stage downstream (O_t^{i-1}), shown in Eq. (6). Eq. (7) and (8), define the target ($TWiP_t^i$) which considers the lead time (Ld_i) and demand forecast ($\widehat{D}_t^i$), and the target inventory level (TI_t^i) which considers the safety stock factor (ε_i) and demand forecast ($\widehat{D}_t^i$). Accordingly, echelon i places an order (O_t^i) to echelon $(i+1)$ with an order interval of (R =1) at the end of each review period which is calculated by the forecasted demand plus the difference between the target work-in-progress and the current work-in-progress and the difference between target inventory level and the current inventory level as in Eq. (9).

$$SR_t^i = min\left\{O_t^i + B_{t-1}^i;\ I_{t-1}^i + SR_{t-Ld_i}^{i+1}\right\} \qquad (1)$$

$$I_t^i = I_{t-1}^i + SR_{t-Ld_i}^{i+1} - SR_t^i \qquad (2)$$

$$B_t^i = B_{t-1}^i + O_t^i - SR_t^i \qquad (3)$$

$$WiP_t^i = WiP_{t-1}^i + SR_t^{i+1} - SR_{t-Ld_i}^{i+1} \qquad (4)$$

$$\widehat{D}_t^{i=1} = \alpha\, D_t + (1-\alpha)\, \widehat{D}_{t-1}^{i=1}, \text{ for } (i=1) \qquad (5)$$

$$\widehat{D}_t^i = \alpha\, O_t^{i-1} + (1-\alpha)\, \widehat{D}_{t-1}^i, \text{ for } (i>1) \qquad (6)$$

$$TWiP_t^i = Ld_i \widehat{D}_t^i \qquad (7)$$

$$TI_t^i = \varepsilon_i \widehat{D}_t^i \qquad (8)$$

$$O_t^i = \widehat{D}_t^i + \left(TWiP_t^i - WiP_t^i\right) + \left(TI_t^i - I_t^i\right) \qquad (9)$$

$$O_t^i \geq 0 \qquad (10)$$

$$SR_t^i = O_t^i, \text{ for } (i=4) \qquad (11)$$

$$OVR_i = \frac{\sigma_{O_i}^2}{\sigma_D^2} \qquad (12)$$

Eq. (10) and Eq. (11) represent the non-negative constraint for orders and the unlimited raw materials for supplier, respectively. Finally, Eq. (12) introduce the calculation of the BWE which is the variance of orders placed by echelon i to its provider ($\sigma_{O_i}^2$) relative to the variance of echelon i customer demand (σ_D^2) (Chen et al. 2000).

SIMULATION RESULTS

We carried out simulation under two scenarios: (i) NIS (ii) CDIS-BCT. The order policy follows equation (1) through (9), with different smoothing factor (α), lead time (Ld) and safety stock (ε) for each echelon which have been generated randomly using R programming language (see Table 1). NetLogo 6.3.0 software is used for modelling and simulation (https://ccl.northwestern.edu/netlogo/). The model assumes that the decisions are made weekly, and lead-time is measured in weeks (Sterman, 1989). We ran each simulation 500 weeks to represent the SC operation in a 10-year period. Each scenario is based on ten repeated runs with random initialization seeds.

Parameters	Retailer	Wholesale	Producer	Supplier
Smoothing factor (α)	0.742	0.47	0.291	-
Lead time (Ld)	3	4	1	3
Safety stock factor (ε)	1	4	4	-

Table 1: Simulation Parameters for each echelon

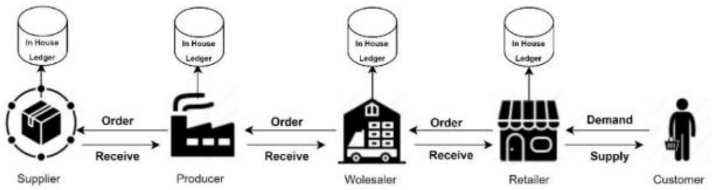

Figure 1: Information flow in traditional supply chain

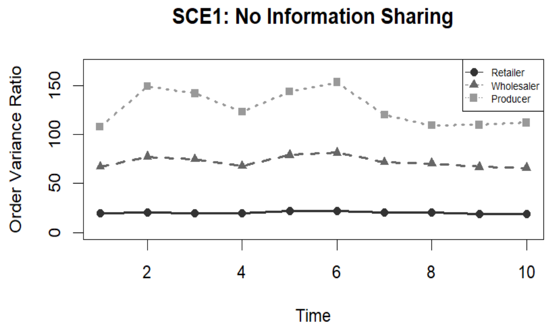

Figure 2: The order variance ratio for supply chain echelons with NIS

No Information Sharing - Traditional supply chain

In a TSC each echelon has its own ledger, and the information flow follows a sequential, linear manner among SC echelons (see Figure 1). As Figure 1 shows, each echelon typically shares orders information directly with the immediate next entity in the SC. This sequential sharing is often centralized, relies on trust between parties, and can lead to information silos or limited visibility into the overall SC. Therefore, in this case, the retailer is the only echelon who has access to the customer demand information (CDI) (see Eq. (5)). On the other hand, the upstream echelons don't have full access and visibility to the end customer's demand. As a result, they rely on the order received from the downstream echelon to forecast the demand (see Eq. (6)) and manage their inventory. Particularly, in each period t, the retailer ($i = 1$) receives customers demand (D_t) and fulfils it from its on-hand-inventory and then issues an order (O_t^i) to the respective wholesaler ($i = 2$) at the beginning of period t according to its current inventory level. The producer ($i = 3$) then gets an order from the wholesaler. The producer's places an order to the supplier ($i = 4$) which is later received after a lead time (Ld).

To examine the BWE occurrence in the initial scenario, we calculated the OVR for the retailer, wholesaler, and producer (see Figure 2). Figure 2 shows the OVR of the retailer, wholesaler, and the producer with NIS. It is evident that the OVR amplifies as one moves from retailer upstream to wholesaler and producer over time. Particularly, the retailer's OVR remains relatively constant. Conversely, wholesaler and producer order variances realize greater fluctuations. Therefore, a strong BWE effect is present in this SC as no information is shared. In other words, upstream echelons have no excess or full visibility of CDI, leading to significant fluctuations in demand and order quantities that increase substantially.

Time	OVR.R	OVR.W	OVR.P
1	19.93707	66.90601	107.696
2	20.61015	77.39321	149.0072
3	19.6183	74.59651	141.7656
4	19.47578	67.82925	122.9644
5	21.69258	79.02905	143.5222
6	21.71001	81.40133	153.0394
7	20.45271	71.76943	119.8891
8	20.74564	70.30994	109.2064
9	19.22147	66.7964	109.7791
10	18.59378	65.83941	111.8771
AVG	**20.26575**	**73.187054**	**117.87466**

Table 2: The order variance ratio with NIS

In Table 2, the OVR across the SC levels provide insights into the BWE. The calculated averages reveal a progressively increasing trend in variability amplification from the retailer to the wholesaler and further to the producer. With an average OVR of approximately 20.27 at the retailer level, there's a relatively lower degree of variability amplification. However, at wholesaler level, the average OVR of around 73.19 indicates a notable increase in variability. The producer level displays the highest average OVR at approximately 117.87, indicating a substantial amplification of variability from the wholesaler to the producer, likely caused by information delays and intensifying demand distortions as orders progress upstream in the SC. The increasing OVR values from the retailer to the wholesaler and further to the producer suggest that small fluctuations in actual demand at the consumer level are being magnified as they move upstream, leading to larger swings in orders which cause the BWE occurrence.

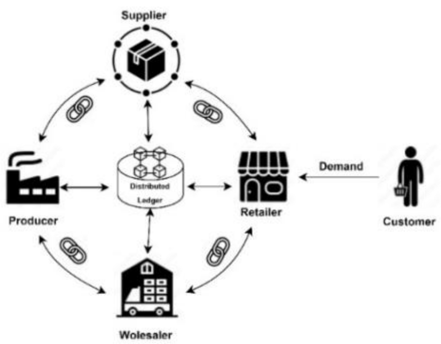

Figure 3: Information flow in BCT-based supply chain

Demand Information sharing -blockchain-based supply chain

In this scenario, a decentralized IS structure is applied using the distinct features of BCT: distributed ledger, smart contracts, cryptography, and consensus algorithms. The proposed model involves four SC echelons that collaborate by sharing CDI. All echelons are assumed to use permissioned BCT and smart contracts for managing orders (Hyperledger 2022). This means, access is only open to echelons authorized as a part of the SC. The advantages of implementing BCT over the TSC is the visibility of CDI and

immutability across SC echelons. Additionally, BCT as a shared and public ledger, enables all SC echelons to access the same CDI and enhances transparency, security, efficiency, immutability, and trust among SC echelons. Relying on BCT features, CDI become accessible and not subject to any tampering which greatly resolves the problem of information asymmetry as a main cause of the BWE occurrence (see Figure 3).
Figure 3 illustrates the flow of information in BCT-based SC. In this scenario, the retailer receives the demand from the end customer. He shares the CDI with other upstream echelons in the blockchain network. Upstream echelons use such information to manage their inventories and forecast the demand, which is made public by using BCT. In contrast to the base scenario (NIS), the same equations (1)-(9) are used except for Eq. (6). In other words, instead of using Eq. (6), the upstream echelons calculate their order-up-to level and forecast the demand employing Eq. (13) relying on the mean and variance of actual CDI, rather than the mean and variance of retailer orders. Eq. (13) consist of CDI that have been shared by retailer on BCT network and the upstream initial demand forecast. That's to say, the retailer orders are the actual customer demand when uploaded and verified in blockchain network. To illustrate the process of sharing CDI via BCT, Figure 4 highlights the implementation of BCT features and how they redesign the information flow in TSC.

$$\hat{d}_t^i = \alpha D_t + (1-\alpha)\widehat{D}_{t-1}^i \,, for\; i > 1 \qquad (13)$$

Figure 4 shows the proposed working process of CDIS-BCT which occurred in the seven steps to add the new block (transaction) in BCT network as follows:

Step 1: The retailer receives the CDI in time t.
Step 2: The retailer encrypts the CDI using encryption algorithm.
Step 3: Once the CDI encrypted, the retailer creates new transaction as block including CDI and order details.
Step 4: The CDI broadcasted on blockchain network which can be seen by upstream echelons.
Step 5: Upstream echelons use the retailer's encryption key to decrypt CDI.
Step 6: Once the CDI block decrypted by upstream echelons, they access and verify the authenticity and reliability of CDI.
Step 7: All SC echelons have access to the same CDI which is permanent and unchangeable record.

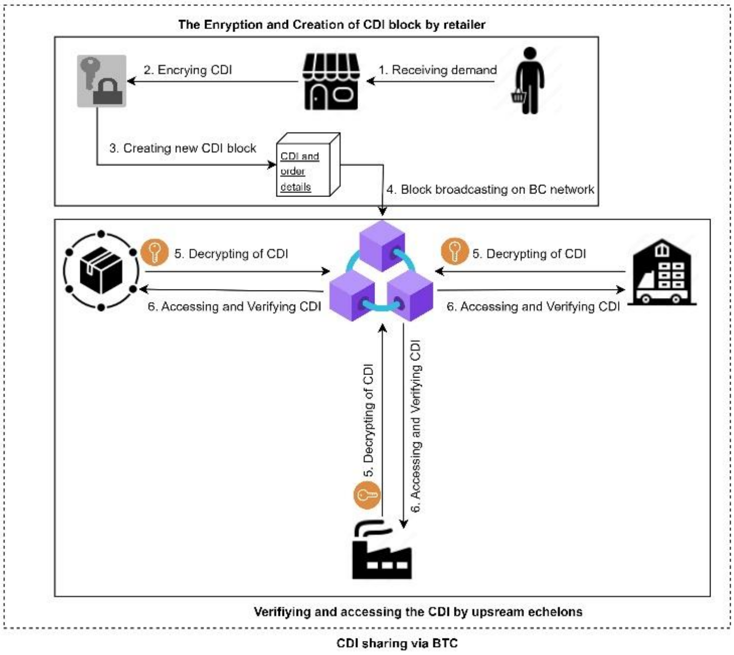

Figure 4: Customer demand information sharing process via blockchain technology.

To investigate how BCT via sharing CDI might mitigate the BWE we also calculate the OVR for the retailer, wholesaler, and producer (see Figure 5).

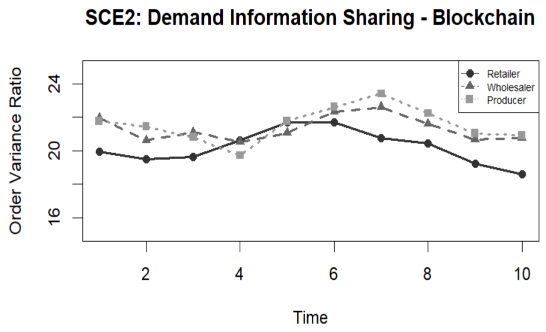

Figure 5: The order variance ratio for all echelons in CDIS-BCT

In Figure 5, we can notice the reduction of OVR for upstream echelons. In other words, the BWE is reduced significantly when the retailer shares CDI with upstream echelons after implementing the BCT. Comparing both scenarios, scenario 1 (NIS), a significant BWE occurred with considerably higher average OVRs at the wholesaler and producer levels, indicating substantial variability amplification and SC inefficiencies. In contrast, scenario 2 (CDIS-BCT), exhibits lower average OVRs across all levels, suggesting a notable stabilization and potential mitigation of the BWE, particularly evident in reduced variability amplification across upstream echelons. In other words, the BWE mitigation becomes more pronounced as one moves upstream towards the producer which agrees with previous literature results (Jeong and Hong 2019; Shaban et al. 2020).

Time	OVR.R	OVR.W	ORV.P
1	19.93707	21.94821	21.76315
2	19.47578	20.61491	21.43782
3	19.6183	21.08843	20.79927
4	20.61015	20.51726	19.70828
5	21.71001	21.06332	21.76647
6	21.69258	22.3149	22.61195
7	20.74564	22.61329	23.40033
8	20.45271	21.59896	22.23036
9	19.22147	20.6715	21.03533
10	18.59378	20.75632	20.91831
AVG	**20.20574**	**21.31870**	**21.56712**

Table 3: The order variance ratio with CDIS-BCT

Table 3 shows the OVR after implementing BCT. After implementing BCT for sharing CDI, the average OVRs across the SC levels show a different picture. As shown, the average OVRs depict a notable stabilization and potential mitigation of the BWE. At the retailer level, the average OVR remains consistent at around 20.21, indicating sustained minimal variability amplification due to improved Information flow structure. Moreover, the average OVRs of the wholesaler and the producer exhibit a significant reduction of approximately 21,32 and 21,57 respectively. That means, the implementation of BCT appears to have positively influenced the SC performance in terms of the BWE mitigation. Additionally, better synchronization and distortion reduction in CDI is appeared resulting in slightly controlled variability amplification, particularly evident at wholesaler level and producer level. Overall, the adoption of BCT demonstrates promising strides in controlling the BWE.

CONCLUSION

An ABM approach is developed to investigate how CDI-based BCT influences the mitigation of the BWE with the focus on IS visibility and accessibility in the whole SC. Two scenarios have been considered: NIS and CDIS-BCT. The BWE is measured using the OVR for the retailer, wholesaler, and producer in both scenarios. To improve the IS flow, we adopted a permissioned blockchain is a serial SC configuration. The simulation results show that CDI via BCT has a clear advantage on BWE mitigation in comparison with NIS. This is attributed to the distinct features of the BCT as an enabler to improve CDI for upstream echelons and improve the overall SC performance. Additionally, accessing CDI by upstream echelons reduces the BWE significantly as the numerical results show with greater OVR reduction for upstream echelons (the wholesaler and the producer). In conclusion, CDIS-BCT has improved in SC which results in BWE reduction. However, several limitations "which are mainly related to the assumptions made" can be observed and pave the way for new future research. We have considered the exchange of only one type of information (actual demand information). Future work could analyse other types of information IS where they are exchanged among SC partners. In addition, in our model we assume that the SC structure is serially connected with four echelons, thus, analysing the performance of the blockchain-IS structures in divergent and convergent SC could be another research avenue. Therefore, assuming correlation may lead to different findings in terms of investigating partial IS in SC. Another future research could be enriching the model by assuming limited capacity for both the supplier and the producer. In addition, a comparison between bi-lateral and uni-lateral IS and how this could affect the BWE via BCT could be a future research venue. Finally, the way information is handled mathematically must be further investigated and possibly new equations be derived.

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The Effect of Blockchain Technology on Trust within Supply Chain Partners: The Mediating Role of Supply Chain Transparency

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INTRODUCTION

Since the emergence of Bitcoin, a digital cryptocurrency, in 2008, Blockchain technology (BCT) has garnered significant attention from various researchers and practitioners, becoming a central point of interest (Dabbagh et al., 2019). BCT is digital ledger that is designed to be resistant to tampering as it is implemented in a decentralized manner, meaning there is no central authority controlling it (Yaga et al., 2019). Hence, BCT is considered an innovative and potentially transformative technology that has the capacity to revolutionize the global supply chain (SC) (Biggs et al., 2017).

Storing decentralized records on a BCT platform increases transparency in the flow of process status information, leading to enhanced operational efficiency and enhanced performance for the whole SC (Centobelli et al., 2022; Francisco and Swanson,2018). SC transparency is described as the combination of visibility and information sharing, enabling a clear view of the entire supply chain which is essential for effectively managing and controlling global SC (Zelbst et al,2019). As previous literature frequently highlights the lack of trust as a significant challenge for effective collaboration between SC partners (Hellani et al., 2021). Studies in the field of Operations and Supply Chain Management propose that distributed ledger technologies, particularly BCT has the potential to enhance trust and facilitate trade in environments where trust is lacking (Baharmand et al., 2021). Thus, BCT fosters and enhances trust by offering transparency in transactions among SC partners (Kavaliauskiene et al., 2021).

Organizations are still uncertain about accepting the high cost of implementing BCT because benefits on the SC have not yet been proven (Ghode et al., 2020). As the decision whether to adopt BCT or not should involve a comprehensive evaluation process that encompasses the entire SC and involves all relevant actors (Baharmand et al., 2021).

Accordingly, this paper aims to examine the effect of BCT on SC trust among SC partners by the mediation of SC transparency. By conducting quantitative research using survey approach to statistically analyze such impact from the perspective of SC professionals who have experience and knowledge about SC management, BCT, and trust and transparency within SC partners.

Literature Review

Blockchain Technology

A widely recognized definition of BCT, coined by Don and Alex Tapscott, states that it is a secure and unchangeable digital record of transactions which can be programmed to not only store financial transactions but also any valuable information (Golosova and Romanovs, 2018). BCT was initially recognized as a platform for overseeing Bitcoin -a digital cryptocurrency, yet currently BCT evolved beyond just currency management to be a novel computing and information flow paradigm, carrying extensive implications for the future advancement of SC management (Saberi et al., 2019). Despite the proliferation of blockchain development projects, research within the blockchain field is still in its infancy (Garg et al., 2021).

BCT has various types such as public BC and private BC. The public blockchain (BC) is a decentralized and inclusive ledger system that operates without any restrictions or permissions, allowing anyone with access to the network to be authorized and obtain data or be a part of the chain (Paul et al., 2021). Prominent examples of public blockchains include Bitcoin and Ethereum, among others (Komalavalli et al., 2020). While Private BC emerged as an effort to enhance performance and exert greater control over users (Ghiro et al., 2021). It operates as permissioned ledgers, limiting access solely to selected participants within the network (Komalavalli et al., 2020). Experts suggest that private BCs can be implemented in various use cases such as voting systems and SC management (Paul et al., 2021).

SC field presents a typical application for BCT, as BCT can change the whole chain providing a more transparent and collaborative SC building trust and improving security (Niu and Li, 2018). As BCT can be a problem solver for many challenges currently faced by supply chains in terms of traceability of information and security of information (Lim et al., 2021).

Supply Chain Transparency and Trust

SC is a network of interconnected organizations engaged in various processes and activities, both upstream and downstream, that create value in the form of products and services delivered to the end consumer (Stadtler and Kilger, 2014). Thus, SC management involves the coordination and control of resources such as materials, finances, personnel, and information, both internally and across the supply chain, with the aim of optimizing customer satisfaction and gaining a competitive advantage over rivals (Shukla et al., 2011).

SC transparency refers to the act of a company providing information to all SC partners which includes supplier, distributers, consumers and even investors (Sodhi and Tang, 2019). Enhanced SC transparency usually invites public scrutiny and pressures the SC partners, but also enables organizations to monitor overall performance across the SC and address specific issues such as suppliers' sustainability hence improving SC sustainability (Chen et al.,2019).

SC success relies on a strong level of trust and a deep commitment among SC partners (Kwon and Suh, 2004). Yet SC Trust presents a multifaceted challenge as it is difficult to attain trust within SC networks as such networks are frequently intricate, involving numerous partners with a wide array of products (Kshetri and Voas, 2019). Then in order to build trust, it is crucial to facilitate transparency throughout the SC, enabling individuals and companies to track the origins of their products along with any kind of information related to these products (Hellani et al., 2021).

Effect of Blockchain Technology on Supply Chain Transparency and Trust

The utilization of BCT in SC ensures the security and accessibility of information, leading to the transparent sharing of information among SC partners (Zelbst et al.,2019). Furthermore, investing in emerging supply chain transparency technologies like BCT allows organizations to achieve improved visibility among SC partners' activities which can minimize risks within the supply chain, resulting in greater efficiency (Montecchi et al., 2021).

BCT reliability and transparency would definitely influence material and information flow among SC partners, offering a major rethinking of SC current practices (Saberi et al., 2019). Hence multiples big consumer goods organizations are currently exploring the adoption of BCT to benefit from its traceability and transparency advantages such as Walmart teaming up with Nestle, Dole, Unilever, and Tyson to test "farm to table" blockchain system, also Carrefour is testing the adoption of blockchain in organic foods SC (Chang et al., 2022).

And based on study by Wang et al. (2019) -interviewing SC experts to get insights about BCT implementation within SC field- experts suggest that implementing BCT into SC would lead to secured information sharing hence building trust between SC partners.

As BCT is composed of interconnected encrypted blocks, where created blocks cannot be altered or deleted without breaking the chain on the network which ensures transparency and trust over the network (Queiroz et al., 2020; Gurtu and Johny, 2019). All network participants have the same copy of a ledger containing list of transactions, allowing for auditability, traceability, and ensuring fairness and ease of access to data within the network (Kouhizadeh and Sarkis, 2018). Such transparency create trust and reduce fraud, additionally users can choose either remain unidentified or provide identification (Wang et al., 2019). As such transparency facilitate the traceability of information across multiple nodes and create a technology-based trust among group of parties (Agrawal et al., 2021).

Furthermore, such enhanced transparency can lead to enhanced consumers' trust in the organization which is considered a valuable competitive advantage (Lim et al., 2021).

Research Problem

Over the years, SC systems enabled by BCT has received significant attention by researchers and practitioners as well, considering it one of most promising technologies for providing traceability-related services in SCs (Dasaklis et al., 2022). Although significant changes can be achieved by implementing BCT within SCs, the literature about BCT in the SC field is still in early stages (Queiroz et al., 2020). Besides, BCT implementation in SC still requires a rigorous academic investigation to understand the extent to which it creates values for the organizations (Tokkozhina et al., 2022). Moreover, there is a research need to further investigate the role of blockchain technology in enhancing trust, traceability, and transparency within public and private companies operating in developing countries (Centobelli et al, 2022).

Accordingly, this paper aims to examine the effect of BCT on SC trust among SC partners by the mediation of SC transparency. Furthermore, this paper focusses on emerging economies, with Egypt as a sample for an emerging economy from the middle east and north Africa (MENA) region. As by reviewing previous literature, Kamble et al. (2020) have stated country contexts might lead to different significant results regarding BCT implementation in SC.

In accordance to the previously mentioned research objective, the conceptual framework is presented in Figure 1 and the developed hypotheses are as follow;

H1: There is a relationship between blockchain technology and supply chain trust.

H2: There is a relationship between blockchain technology and supply chain transparency.

H3: There is a relationship between supply chain transparency and supply chain trust.

H4: The relationship between blockchain technology and supply chain transparency is mediated by supply chain trust.

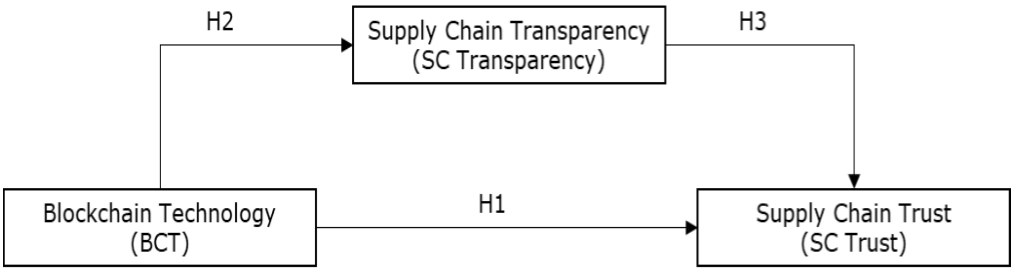

Figure 1: Conceptual framework of this study

Research Methodology

As the aim of this study is to examine the impact of BCT on trust within supply chain partners, with a specific focus on the mediating role of SC transparency, this study adopts an exploratory research approach through a quantitative method using surveys to collect data from professionals in the field of BCT and SC -industry experts and professionals- in organizations operating in Egypt. Survey instrument was developed based on validated items collected from the previous literature, all constructs and measurement items were selected carefully in order to ensure their fit into the research model and to satisfy the research objective as shown in Table 1.

The population from which the sample was selected consists of supply chain professionals working in organizations operating in Egypt. Using, nonprobability sampling methods - convenience sampling and snowball sampling.

Data were collected through an online survey using google forms via social networking websites, mostly through the professional network platform "LinkedIn". Participation was kept voluntary with follow up messages and emails from the researcher at frequent interval. Online surveys are considered beneficial for collecting many responses in a short time interval with lower expenses than traditional paper-based surveys (Kamble et al., 2019; Sekaran and Bougie, 2013).

Construct	Measurement item	Source
Blockchain technology (BCT)	I find blockchain useful in our supply chain processes.	(Queiroz and Wamba, 2019)
	As an organization, we might consider using blockchain technology in supply chain processes.	
	As an organization, we are planning to use blockchain technology in supply chain processes.	
Supply chain trust (SC Trust)	Using blockchain technology in supply chain will increase our trust in supply chain partners.	(Doney and Cannon, 1997)
	Using blockchain technology in supply chain can help us believe the information that the vendor provides us.	
	Implementing blockchain technology in supply chain practices can contribute to building trust with vendors.	
	Using blockchain technology will make suppliers trustworthy.	
Supply chain transparency (SC Transparency)	I believe blockchain enabled-supply chain processes would be transparent.	(Queiroz and Wamba, 2019)
	I believe using blockchain technology in supply chain will provide me with in-depth knowledge about my supply chain partners' activities.	
	I believe using blockchain technology in supply chain with deep access to understand how my supply chain partners work.	

Table 1: Survey items for survey development

A sample of 32 SC professionals were considered for this research study. This sample size satisfies and exceeds the minimum requirement of ten observations per construct according to the rules of thumb.

After reaching 15 respondents -exceeding 10% of the targeted sample size as recommended by Kim and Shin (2019), some statistical pilot tests were performed such as test of interitem consistency reliability using the Cronbach's coefficient alpha. Results showed that the instrument used is suitable for the research objective and statistical approportionates do exist.

Quantitative data analysis includes various statistical tests from which the researcher chooses the most convenient according to type of data collected and type of hypotheses being tested. In this research, IBM SPSS (Statistical Package for Social Sciences) Statistics 19 quantitative analysis software was utilized.

Yet before conducting these statistical tests, validity and reliability need to be tested. However, since all items used in this survey are adopted from validated surveys developed by previous articles, validity testing was overlooked. Regarding research reliability, the interitem consistency reliability was tested using Cronbach's alpha (α), which is a reliability coefficient that indicates how well the items in a set are correlated to one another, the closer Cronbach's alpha to 1 the better the reliability is (Sekaran and Bougie, 2013).

Analysis was conducted to confirm the relationship between variables such as correlation analysis through developing a correlation matrix using Pearson correlation matrix. Finally, to test the significance of relationships between independent variables and dependent variables explained in the developed conceptual framework presented in figure 1, simple and hierarchal regression was performed.

Results and Analysis

After finalizing the data collection, reliability testing was conducted through testing of interitem consistency reliability using the Cronbach's coefficient alpha. The results demonstrate that the Cronbach's Alpha value for the BCT and SC trust constructs were acceptable exceeding 0.7, indicating excellent reliability. However, the SC transparency construct's Cronbach's Alpha value was questionable, yet it was overlooked since the overall items of this measures are considered reliable, and due to inability to change the items and recollect data.

Pearson Correlation Coefficient was used to examine the relationship between BCT as independent variable and SC trust and SC transparency as dependent variables. As well as the relationship between SC transparency as independent variable and SC trust as dependent variables. Results showed that there was a strong positive significant correlation between BCT and SC trust (r=0.899, p=0.000). Also, results showed that there was a moderate positive significant correlation between BCT and SC transparency (r=0.481, p=0.005).

In addition to that, results showed that there was a moderate positive significant correlation between SC trust and SC transparency (r=0.485, p=0.005).

To test for H1, H2, and H4, hierarchal regression was performed to test whether SC transparency mediates the relationship between BCT and SC trust. While to test for the relationship between SC trust and SC transparency – testing for H3, simple regression was conducting and results for hierarchal regression are presented in Table 2, Table 3 and Table 4 and results for simple regression are presented in Table 5, and Table 6.

Model	R	R square	Adjusted R Square	Std. Error of the Estimate	Durbin-Waston
1	0.297[a]	0.088	0.082	1.367	
2	0.636[b]	0.404	0.396	1.108	2.035

a. Predictors: (Constant), BCT, b. Predictors: (Constant), BCT, SC Transparency

Table 2: Summary of regression model - Hierarchal Regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.805	1	12.805	126.393	**.000[a]**
	Residual	3.039	30	0.101		
	Total	15.844	31			
2	Regression	12.863	2	6.431	62.568	**.000[b]**
	Residual	2.981	29	0.103		
	Total	15.844	31			

a. Predictors: (Constant), BCT, b. Predictors: (Constant), BCT, SC Transparency

Table 3: Regression model ANOVA - Hierarchal Regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.483	0.343		1.409	.169
	BCT	0.914	0.081	0.899	11.242	.000
2	(Constant)	0.097	0.618		.156	.877
	BCT	0.880	0.093	0.866	9.426	.000
	SC Transparency	0.123	0.164	0.069	.753	.458

Table 4: Regression model coefficients - Hierarchal Regression

From the ANOVA table presented in Table 3, the regression model is significant indicating that both BCT and SC transparency are significant variables influencing to SC trust. Furthermore, results showed that in the presence of SC transparency the R^2 of the model has increased significantly from 0.088 to 0.404 as seen in Table 2, suggesting that around 40.4% of the variation in SC trust can be explained by BCT and SC transparency.

Additionally, in the presence of SC transparency, the direct relationship between BCT and trust has slightly weakened as shown in coefficients table – Table 4 – (Beta = 0.899, P=0.000 in model 1 and Beta = 0.866, P=0.000 in model 2) yet in both cases the

relationship was significant indicating that SC transparency is a partial mediator for the relationship between BCT and SC trust. Hence supporting H1, H2, and H4.
Results for simple regression between SC transparency and SC trust showed significance with $R^2 = 0.235$, indicating that approximately 23.5% of the variance in SC trust can be explained by SC transparency as present in Table 5 and Table 6. Hence, supporting H3 as well.

Model	R	R square	Adjusted R Square	Std. Error of the Estimate
1	0.485[a]	0.235	0.210	0.635

a. Predictors: (Constant), SC Transparency
Table 5: Summary of regression model - Simple Regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.805	1	12.805	126.393	**.000[a]**
	Residual	3.039	30	0.101		
	Total	15.844	31			

a. Predictors: (Constant), SC Transparency
Table 6: Regression model ANOVA - Simple Regression

DISCUSSION
Statistically significant findings of this study can be summarized into four main themes. First, the direct relationship between BCT and SC trust, second, the direct relationship between BCT and SC transparency, third, the direct relationship between SC trust and SC transparency, and finally, the partial mediation role of SC transparency on BCT and SC trust.
Regarding the direct relationship between BCT and SC trust, findings suggested that BCT implementation in SC has a positive significant impact on SC trust. Hence, BCT can be considered as one of the significant predictors for SC trust. While for the direct relationship between BCT and SC transparency, the analysis of empirical data collected in this study revealed that using BCT in SC could facilitate the flow of information within the SC which in return ease information sharing between SC partners- suppliers, manufacturers, and customers hence enhancing SC transparency between SC partners. As BCT allow SC partners to have a decentralized ledger meaning that all partners will have the same exact copy of database or information. This decentralized structure in BCT improves transparency of information.
Concerning the direct relationship between SC trust and SC transparency, findings investigating the relationship between both variables were significant, verifying such relationship. So that improvements in SC transparency can lead to increased level of information sharing between SC partners hence enhanced SC trust. Finally, for the partial mediation role of SC transparency on BCT and SC trust, as findings confirmed that such increase in the level of SC transparency can lead to increased trust among SC partners. This can be explained by the assumption that higher information transparency will reduce the gap of information visibility across partners leading to increased mutual trust. Hence findings of this research study confirmed the mediating role of SC transparency on the relationship between BCT and SC trust,

CONCLUSION AND FUTURE RECOMMENDATION
This paper aimed to investigate the effect of BCT on trust with SC partners, with a specific focus on the mediating role of SC transparency. Quantitative research approach was adopted using survey to gather data from a diverse range of SC professionals. Through statistical quantitative analysis of survey responses, the research findings confirmed that BCT has positive effect on SC trust. As the decentralized and transparent nature of BCT

allows for increased visibility and accountability, fostering trust among SC partners. Furthermore, findings also revealed that the impact of SC transparency, as a mediating factor, on the relationship between BCT and SC trust was partial mediation.
This finding draws focus on the need for a better understanding of trust-building mechanisms within SC partners in the context of BCT implementation in SC field. As, it is crucial to understand while SC transparency remains important, it may not be the sole driver of SC trust when BCT is employed. Alternative mechanisms, such as immutability and security features of blockchain, as well as the implementation of smart contracts, should be duly considered, which might be promising area for future research directions.
It is important to acknowledge the limited sample size of this study, which may impact the generalizability of the findings. Therefore, it is advisable to interpret the conclusions with caution, considering the constraints imposed by the sample size.

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Autonomous Processes in Logistics

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INTRODUCTION

As logistics chains are getting increasingly complex, they get at the same time more and more vulnerable to external factors (Scholz-Reiter et al., 2004). As we have seen during and after the Covid-19 crisis, the mitigation of such vulnerabilities is rather difficult. The starting point to avoid logistics vulnerabilities is usually in the planning phase, where logistics scenarios are generated to deal with various aspects like resilience, efficiency, and effectivity (Carvalho et al., 2012; Terzi & Cavalieri, 2004). However, one could argue that in complex logistics strategies, the operation almost never goes according to plan, since there are so many deviations possible in each scenario (Dorer & Calisti, 2005).
To cope with these deviations normally replanning is required. Currently this means however, to run a simulation which can, for complex systems and by including all the different factors mentioned above, take several hours. In general, a central planning resource seems to be the wrong approach for a highly distributed network of possible deviations. Additionally, real-time data integration and adaptive algorithms are becoming increasingly essential to handle these complexities efficiently. Implementing decentralized and autonomous systems could potentially reduce the time required for replanning and increase overall system resilience. Moreover, continuous monitoring and rapid response mechanisms are crucial for maintaining the flexibility and robustness of logistics chains in the face of unforeseen disruptions.

METHODOLOGY

The article aims to identify the current State-of-the-Art in distributed logistics planning. The starting points for this article are the concepts of holons and monads, which are autonomous entities that can represent logistics objects. In the article we investigate to which extend these concepts can be used to deal with deviations in logistics network. The goal hereby is to enable an individual representation of a logistics object, to react to a deviation on its own (e.g., based on a set of rules and objectives). Thus, solving a problem locally in order to avoid a more global impact of a deviation and reducing the need for a whole new planning of the global logistics scenario.

CONCEPTS

Monads

The term "monad" comes from philosophy and was popularized in particular by Gottfried Wilhelm Leibniz (1720). Originating from the Greek word monas meaning unit, Leibniz used the term to describe an elementary, indivisible unit or substance that forms the fundamental building blocks of reality. Leibniz developed the concept of monads as part of his metaphysics, a philosophical discipline that deals with the fundamental principles of existence and reality. Even before in the ancient Greek mathematics, monad was used to describe the metaphysical origin of the numbers (Duffy, 2010). According to Leibniz, monads consist of two principles that are independent in themselves and only form a complete substance or monad when they are combined: The innermost centre of a monad, i.e. the mathematical point in which the "soul" is located, constitutes the internal form of the monad. However, this form cannot exist as such, but is implanted or incarnated in a physical point, i.e. a sphere that is infinitely small and forms, as it were, the outer shell of the monad. It consists of a special matter that Leibniz calls first matter (Rohde, 2002). For Leibniz, each monad was a unique, independent being that had its own inner states and activities without being affected by external influences. This idea contrasts with the

mechanistic world view of his time, which saw the world as a collection of material particles that interact with each other through physical forces. Nowadays, monads are commonly known in the programming world. Although the term monad has a different meaning in programming than in philosophy, there are still some parallels. As in philosophy, monads in programming are fundamental, indivisible units that fulfil a specific function. They serve as building blocks from which more complex structures can be constructed and allow effects to be managed within a controlled and structured framework (Odersky, 2021).
The idea of the monad was later taken up in various scientific disciplines. In logistics, a monad represents a single, indivisible entity that can be identified, tracked and managed within a logistics system. These can take various forms, such as individual parcels, products, containers or vehicles, depending on the context and level of consideration. Monads form the basis for the analysis and optimization of logistics processes by serving as a starting point for tracking and managing goods.

Holons

The concept of the holon was coined by the Hungarian-British writer and scientist Arthur Koestler. The word itself combines the Greek work holon, which can be translated to whole, and the suffix on, which indicates part or particle. Koestler first used the term in his 1967 book "The Ghosts in the Machine" to describe something that can be seen as both a whole and a part. On the one hand, holons behave as autonomous entities and are for instance able to make own decisions; On the other hand, single holons cooperate with others to form self-organized hierarchies of subsystems (Ulieru et al., 2002). A Holon is therefore characterized as a "stable form that survives disturbances, can act in the absence of data, and still functions for the functionality of the bigger whole" (Versteegt et al., 2002, S. 2).
The first major generic architecture was derived by Van Brussel, et al. (1998) and composed following four main holons: (1) product holons, (2) resource holons, (3) order holons, and (4) staff holons. In the past, the concept of the holons was explored for instance in the field of manufacturing (Christensen, 1994) and supply chain management (Ulieru et al., 2002) promising further knowledge in distributed intelligent architectures. Since then, several more architectures have been created to cope with innovative technologies such as clouds or the increasing need for dynamic (Cardin et al., 2018).
In logistics, individual means of transportation, storage facilities or logistical hubs can be considered holons, acting both independently and as part of a larger network that enables the coordination and flow of goods. This dualistic nature of holons makes it possible to better understand and model the complex hierarchy and structure of logistics systems. Specifically, Ounnar & Pujo (2016) define product holons in logistics as the transported goods, order holons as the transportation type of each product and the monitoring of the actual progress of each transport and resource holons as the various modes of used transport.
The combination of monads and holons in logistics enables a holistic view of transportation and supply chains. While monads represent the basic building blocks that are tracked and managed in logistical processes, holons enable a flexible and dynamic structure that makes it possible to manage the complexity and diversity of logistical systems. By combining these concepts, efficient and sustainable logistics solutions can be developed to meet the demands of an ever-changing global economy.

Digital Twins

Similarly to the above-mentioned concepts, Digital Twins are digital models that represent real-world systems or processes in a virtual environment. They are typically categorized into three main subtypes: digital twin prototype (DTP), digital twin instance (DTI), and digital twin aggregate (DTA). The DTP is the digital representation of a physical product or good before it is manufactured; the DTI is the digital twin of each individual instance of a good after it has been manufactured (i.e., is being shipped or used in another manufacturing process or is being sold/used). The DTI is a digital replica with the same functionality and behavior. The DTA is the aggregated data and information from all the individual DTIs. It can be used to provide insights into the physical good categories, involved process, predict its behavior, or learn other (meta-)data of its properties. For logistics process and supply chain management we are considering mainly DTIs and DTAs (Grieves & Vickers, 2017).

Technology

One central technological concept for autonomous process in logistics that adopts monads, holons and agent-based software development as well as instances of digital twins is Intelligent Cargo. Intelligent Cargo's core concept lies in shifting focus from comprehensive system-wide analysis to individual subsystems, aiming for autonomous control that fosters improved resilience and beneficial outcomes. This contrasts with traditional logistics planning where routes are planned ahead, leaving performance evaluation post-shipment with limited real-time adjustments. As deviation chances increase, overall transportation efficiency deteriorates. The complexity of modern supply chains involving multiple actors across various modes (street, sea, air) creates multiple points for delays within the process.

The foundation for Intelligent Cargo's vision involves several initiatives: (1) The Common Framework, a 2010 joint project aiming to establish a standard communication system for logistics, integrating systems like authorities and enabling emerging technologies (Pedersen et al., 2017); (2) e-Freight, a paperless, electronic system utilizing semantic web technologies for efficient information exchange with regulatory bodies and legal considerations in multimodal transport (E-Freight consortium, 2015); (3) The Internet of Things, introduced by Kevin Ashton in 1999, which assigns unique identifiers to real-world objects for worldwide identification and digital connectivity through IPv6 (Ashton, 2009). Ancillary efforts include the Internet of Everything, Intelligent Transport Systems, and ICT for Intelligent Vehicles and Mobility Services, all contributing to cargo intelligence.

In practice, Intelligent Cargo involves equipping cargo items with devices like active RFID chips, smartphones, or specialized hardware that can collect data from surrounding sensors or directly attached sensors. These could be containers, pallets, or transportation units, and the sensor inputs can include GPS for location tracking, temperature sensors for perishable goods, security protection sensors, and access to vehicle or warehouse data bus – on mobile Internet connections - these devices can transmit status updates to back office, perform actions when deviations occur, like re-booking if necessary. The research group SFB 637 of the University of Bremen suggested potential advanced reasoning, such as re-planning cargo routs due to delays or better routes already in the late 1990s. Business level innovations from autonomous processes of Intelligent Cargo detail benefits such as collaborative planning across borders, real-time supply chain re-planning, static supply chain measurements for cost or emission efficiency optimization, and resilience improvement of supply chains. Intelligent Cargo contributes to resilience and robustness by these means and potential benefits (Dobler & Schumacher, 2013).

A continuation of the Intelligent Cargo concept is the technological foundation behind the Physical Internet (Montreuil, 2011). Physical Internet (PI, sometimes stylised as п) is an initiative of various (EU-funded) research projects which uses the Internet and its digital networking technologies for data transfer as an analogy to disrupt the way how goods are routed in supply chains. PI intends to use concepts such as layers, modularity and encapsulation, protocols, or interfaces of data networks and applies them to transportation routes with its principle of п-containers. Promised advantages of PI include the use of IoT-enabled smart green containers, universal interconnectivity, standardisation of п-containers, ease of routing of goods, as well as global, resilient supply chains. The concept has been described extensively, however, several organisational and technical challenges regarding its global roll-out and wider use still exist, mainly the build-up of a global ecosystem for PI and adoption of a wider range of technologies besides IoT.

As mentioned previously, Logistics 4.0 refers to the integration of digital technologies and innovative applications in logistics processes, often seen as an extension or derivation of the Industry 4.0 and digitalisation movements (Winkelhaus & Grosse, 2020). Key characteristic is the enabling of sustainable satisfaction of customer demand without an increase in costs using digital technologies. It might encompass various aspects, including real-time Big Data analytics for optimised routing, reduced storage requirements, autonomous robots for optimised inventory control, real-time information exchange to prevent disruptions, or the use of smart items to avoid information gaps. Some research suggests that Logistics 4.0 can be seen as a combination of logistics and Cyber-Physical Systems (CPS).

E-Freight frameworks promote the seamless and efficient exchange of information in the field of logistics through the integration of regulatory bodies and authorities within an integrated information exchange process (via technologies of the semantic web, i.e. ontologies). The frameworks normally take into consideration legal issues related to co-modal transport networks, ensuring that all parties involved are held accountable for the proper functioning and security of the information exchange process (E-Freight consortium, 2015).

FINDINGS

Nowadays there are several factors that lead to volatile supply chains (Nitsche, 2018). Most recently the Covid-19 Pandemic showed how volatile and insecure logistics processes worldwide are. Therefore, it is of crucial importance to not only focus on new technologies to optimize logistics processes and information flows, but to also improve autonomy and resilience. The article aims to identify the current state of the art in distributed logistics planning, with a particular focus on developments in the field of autonomy. Therefore, several approaches and technologies were introduced. Based on these descriptions, Table 1 was created. It aims to give an overview of the current state of Holons, Monads, Mobile Agents, and Digital Twins in technologies that are Physical Internet, Intelligent Cargo, Logistics 4.0, and e-Freight.
Taking a look at Physical Internet, neither Holons nor Mobile Agents are implemented but merely described. Monads and Digital Twins are conceptualized. However, all approaches intend a high autonomy level which is similar to the Internet.
In comparison, in Intelligent Cargo, Holons and Mobile Agents are partially implemented, Monads are solely conceptualized whereas the state of Digital Twins in Intelligent Cargo is unknown. All approaches aim to be fully autonomous.
The four approaches are rather undiscovered in the concept of Logistics 4.0, solely Digital Twins are partially implemented. Holons, Monads, as well as Mobile Agents are not described in Logistics 4.0. All approaches would target a partially autonomous level.
Concerning e-Freight, all four approaches would be highly autonomous as they would act as replacement of paper in Logistics, alongside Digital Transformation approaches. The implementation of Holons and Monads in e-Freight are described but not implemented. The implementation of Mobile Agents is conceptualized however a concept of the implementation of Digital Twins in e-Freight is missing.

Approach ***Technology /Movement***	**Holons**	**Monads**	**Mobile Agents for Logistics**	**Digital Twins (DTIs** *or* **DTAs)**
Physical Internet	**Implementation:** Described, but not implemented **Intended Autonomy Level:** High (analogy to the Internet)	**Implementation:** Conceptualised **Intended Autonomy Level:** High (analogy to the Internet)	**Implementation:** Described, but not implemented **Intended Autonomy Level:** High (analogy to the Internet)	**Implementation:** Conceptualised **Intended Autonomy Level:** Fully autonomous

Intelligent Cargo	**Implementation:** Described, partially implemented **Intended Autonomy Level:** Fully autonomous	**Implementation:** Conceptualised **Intended Autonomy Level:** Fully autonomous	**Implementation:** Described, partially implemented – uptake missing **Intended Autonomy Level:** Fully autonomous	**Implementation:** Unknown / Not described **Intended Autonomy Level:** Fully autonomous
Logistics 4.0	**Implementation:** Unknown / Not described **Intended Autonomy Level:** Partially autonomous	**Implementation:** Unknown / Not described **Intended Autonomy Level:** Partially autonomous	**Implementation:** Unknown / Not described **Intended Autonomy Level:** Partially autonomous	**Implementation:** Described, partially implemented **Intended Autonomy Level:** Partially autonomous
e-Freight	**Implementation:** Described, but not implemented **Intended Autonomy Level:** High (replacement of paper in Logistics, alongside Digital Transformation approaches)	**Implementation:** Described, but not implemented **Intended Autonomy Level:** High (replacement of paper in Logistics, alongside Digital Transformation approaches)	**Implementation:** Conceptualised **Intended Autonomy Level:** High (replacement of paper in Logistics, alongside Digital Transformation approaches)	**Implementation:** Missing **Intended Autonomy Level:** High (replacement of paper in Logistics, alongside Digital Transformation approaches)

Table 1: State-of-the-Art in distributed logistics planning

As can be seen in Tabel 1 there are several concepts as well as technologies that have the potential to revolutionize autonomy in logistic processes. There needs to be however not just a fitting combination of the suggested concepts and technologies but also a general agreement or standardized approach in order to implement a fully functioning system. A radical paradigm shift is inevitable.

In order to enable autonomy in logistics, the physical internet presents a very good starting point as it provides access to information about goods and logistics resources in a unified manner. However, there are only a few projects that have dealt with the idea of controlling logistics systems autonomously so far (SFB637, iCargo, Euridice). Most of those projects exploit Mobile Software Agents to implement intelligence into the cargo and the involved infrastructure. By that, resources like planes, trucks, hub's, warehouses etc. as well as the cargo itself act as independent agents that can interact freely with each other.

Nevertheless, at the moment there is still no common platform available that would allow the exchange of agents in a standardised way so that a free choice of carriers and logistics modes would be possible. Furthermore, such a system would most probably run against the interest of the many logistics provider because it would cut into their main business.

One of the better known companies that implemented an novel approach comparable to agent-based concepts is Flexport (Patel, 2022), which can be regarded as Uber for freight but in a multimodal way. This platform, however, does not support an agent-based approach and thus acts rather like a third-party logistics operator.

An important question is whether there is a need for a central hub like Flexport to bring together all the information about potential logistics operations or whether it would be more efficient to embark on a peer-2-peer (P2P) mode of operation, where no central platform is needed, and the middleman can be left-out thereby benefitting customers and carriers. Especially technology like Blockchain supports a decentralised approach where contracts are controlled in decentralised systems in a peer-2-peer (P2P) mode of operation.

Although some thorough research has been conducted in the field of autonomous agents for logistics operation and even practical implementations have been introduced, there has not been a significant and segment-changing rollout.
Most of the projects that have implemented Mobile Agents to realize autonomy have only had an internal roll-out in a specific company, thus they could solely be used to control the intra-processes of the company. However, the real potential of this approach could be utilized, if processes from different logistics companies, forwarders and carriers would be intertwined. In this scenario, the real potential of autonomous logistics would be considered, and it remains to be seen whether the typical logistics providers will be the enablers or inhibitors of the change, once such a system is rolled out.

Outlook

Research in the field of autonomous logistics processes is still in its early stages. However, significant potential exists in building on previous advances and integrating both established and emerging concepts and technologies. This approach can enhance autonomy, streamline decision-making, improve resilience, and ultimately reduce costs.

The revised concepts and technologies discussed in this paper highlight the increased potential and new possibilities emerging in the near future. In particular, the field of machine learning stands out as a promising enhancement for the autonomous processes in logistic as well as all intelligent components in logistics. Technologies such as Intelligent Cargo and Mobile Agents can benefit substantially from new machine learning approaches, making the whole supply chain even more independent and self-controlling. Additionally, concepts like the circular economy can greatly benefit from autonomous logistics processes, as these enable traceability and a fully transparent supply chain.

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A Systems Theory Approach to the Performance Analysis of Robotic Compact Storage and Retrieval Systems: An Autostore™ Case Study

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INTRODUCTION

Warehouses in general and storage systems in particular can be evaluated on the basis of just four performance criteria: Time, Cost, Quality, and Productivity (Staudt et al., 2015). Besides productivity (the number of storage and retrieval operations relative to the human and robotic labor assigned to the system in each period), flexibility and scalability (the effort required to adapt the system to new output scenarios) and density (cubic footprint of the storage system for a given quantity of goods have received particular attention in recent years (Zou et al., 2018).

The most dense form of storage, a block storage without any aisles, has the disadvantage that access to the goods is restricted. It requires that all goods in front of those to be retrieved must be removed first. For a long time, block storage was therefore only recommended for last-in-first-out storage of (mostly) single-item quantities of goods per block. The idea that robots could take over the tedious work of digging goods from the block triggered a renaissance of the block storage. In 2004, the AutoStore, a single-block robotic compact storage and retrieval system (RCSRS), revolutionized the design of storage systems and has since become the market leader for RCSRS with more than 1,250 installations worldwide (AutoStore, 2024).

The purpose of this paper is to develop and test a systems theory approach to the performance of RCSRS, using an AutoStore as a case study.

The rest of the paper is structured as follows: First, we show that the literature on RCSRS focuses on the algorithmic improvement of specific parts of the system. Then, we briefly explain our systems theory approach to evaluate the performance of an AutoStore system through a case study. The system analysis is the central part of the paper, where we show how design decisions can permanently influence the output and how few operational levers are available for sustainable performance improvement. We then generalize our findings to provide guidance for designing AutoStore systems that better fit the business and logistics environment and meet their performance goals.

LITERATURE REVIEW

The recent growth of e-commerce is drawing attention to fulfillment activities in warehouses: Picking, packing and shipping. Picking is the most time-consuming activity and accounts for more than 50% of warehouse costs (de Koster et al., 2007). In response to the challenges of order picking, such as increasing demand volumes and staffing issues, the use of automated and robotic solutions is becoming increasingly important, even if picker-to-parts solutions still dominate today (Winkelhaus et al., 2021). Robotics can improve both picker-to-parts and parts-to-picker solutions. In picker-to-parts warehouses, the idea is to replace the human picker with a robot (Bogue, 2016), which requires complex, adaptive, and thus expensive robots. Besides some pilot implementations, the penetration of the market is low (Kauke and Fottner, 2020). In parts-to-picker solutions, automated systems (AS/RS) have been around for several decades, while robotic compact storage and retrieval systems (RCSRS) are relatively new but on the rise (Azadeh et al., 2019; Zou et al., 2018).

Only a very limited number of papers have been published on RCSRS. The AutoStore, the most popular RCSRS, maintains ABC zoning automatically (Galka and Scherbarth, 2021). Although this is correct in general, it does not mean that this ABC zoning is necessarily a favorable one, i.e. one with a steep pareto distribution.

Previous research has mainly focused on operations research approaches. Zou et al. (2018) evaluated dedicated (each stack is dedicated to a specific SKU) and shared storage strategies (different SKUs can be in one stack). Chen et al. (2022) used discrete event simulations to analyze system performance and energy consumption. In all these approaches, it was assumed that a storage bin can only hold one SKU.

Assuming that the RCSRS has a sufficient order inventory at hand, Ko and Han (2022) showed that a rollout heuristic algorithm can efficiently determine the optimal processing order of orders. Cai et al. (2023) used a mixed-integer programming heuristic to reduce the idle time of the robot (travelling empty) and the idle time of the workstations, assuming that the workstations must process the orders in a certain order. The effort required to relocate bins can be significantly reduced by reinforcement learning (Wang et al., 2023).

All of these papers deal with individual parts of the system, such as robots or composition of stacks and take an algorithmic approach, using methods to overcome the computational burden either through simulation or heuristics. Only two papers adopted a more systemic perspective, by listing the factors that influence the performance of an AutoStore (Galka and Scherbarth, 2021; Trost et al., 2022). However, none of these papers address RCSRS from a holistic perspective that includes the stakeholders and their decisions, the storage and information technology with their respective constraints, the product portfolio and its allocation to the bins, and the market and business environment.

METHODOLOGY

According to systems theory, a system is a self-contained group of interrelated and interconnected components within a specific context that fulfills a specific purpose (Kroes et al., 2006). The system under consideration here is an AutoStore cube storage system with its business, logistics and information processing environment (**Fig. 1**), which was designed to contribute around 800 order lines per hour to the logistics operations of a German company, but currently has an output of only 650 order lines per hour.

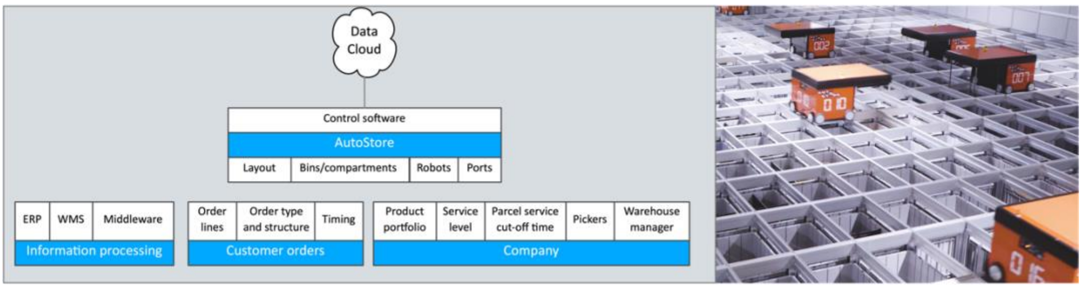

Fig. 1: AutoStore as a system

As the AutoStore clearly failed to meet this performance target, we analyzed its technical and information technology components within the business environment set by the company and its customers. The aim was to (a) understand the reasons for low performance and (b) identify operational measures (available to warehouse managers) and tactical measures (requiring a partial redesign of the system) to improve performance. Generalizing the results of this single-case study should help companies using an

AutoStore and those considering implementing such a system to better understand the drivers and barriers to performance.

SYSTEM ANALYSIS

The AutoStore has a capacity of 11,022 bins. The company has decided to divide close to 40% of the bins into compartments so that they can hold two (2,105 bins), four (984 bins) or eight different SKUs (1,134 bins). 6,799 bins contain only one SKU. In the largest part of the cube, the stacks are 16 bins high, except in the area in which the cube overbuilds the picking ports. This specific layout of the AutoStore offers 876 top-grid positions.

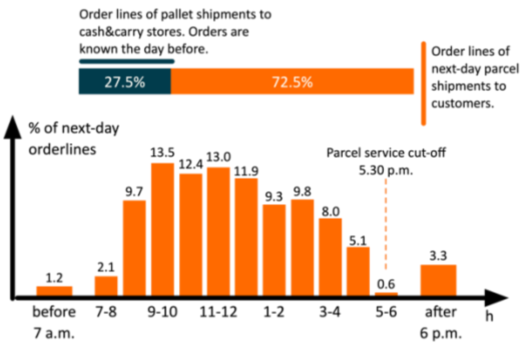

Fig. 2: When order lines are received

Our analysis covered three months in 2023 and was based on 310,586 order lines picked in the AutoStore. The company is faced with two types of orders: (1) large replenishment orders for cash & carry stores that are known the day before picking (27.5% of order lines), and (2) small orders that are received shortly before picking and for which the parcel service's cut-off time of 5.30 p.m. is relevant in order to fulfill the promise of next-day delivery (72.5% of order lines). **Fig. 2** shows when the order lines of the small orders are received during the day. The orders are sent to the AutoStore in waves every 30 minutes.

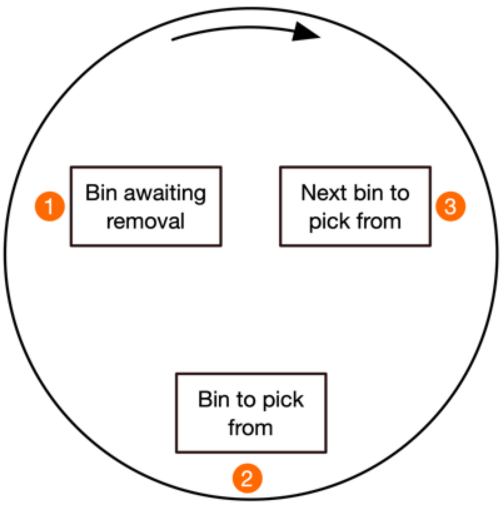

Fig. 3: Carousel port (top view)

The AutoStore has five carousel ports for order picking. A carousel port (**Fig. 3**) can hold up to three bins: (1) the bin from which items have just been picked and which is awaiting removal by a robot, (2) the bin from which picking is to take place, and (3) the next bin to rotate to picking position. The total time for picking from a bin is made up of the bin waiting time (the picker waits for the next bin to be rotated to the picking position) and the processing time (picking and placing in the order bin and any required interaction with the user interface). If we assume a bin waiting time of two seconds (which is the case if a bin is waiting in position 3) and a processing time of 18 seconds, each port can deliver 180 order lines per hour. Obviously, the bin waiting time depends on the performance of the AutoStore, while the processing time is mainly influenced by the goods, side tasks such as removing packaging material, the ergonomics of the user interface and the personal performance of the picker. Therefore, we focus on the waiting time for the bin. To achieve a waiting time of two seconds bins (2) and (3) must be available while a robot is removing the bin from position 1 (**Fig. 3**).

Any robot that is not engaged in removing bins from and feeding bins to the ports can assist in preparing order lines, i.e. digging them out of their position in the stack and placing them on a top-grid position. More frequent retrievals of bins from the lower levels of the stack require a greater amount of digging, so it takes longer to deliver the required bins. In contrast, a greater proportion of bins that can be retrieved from higher levels of the bin stacks enables a higher number of bin retrievals per robot per hour. The bin waiting time becomes shorter the more order lines can be prepared. The more robots working on the grid and the steeper the Pareto distribution, the more order lines can be prepared. Opening another picking port ties up some robots for picking and feeding bins, reducing the number of prepared order lines, while increasing the number of order lines that need to be prepared to keep the pickers busy. Of course, only the order lines that have already been transferred from the WMS to the AutoStore control software via the middleware can be prepared.

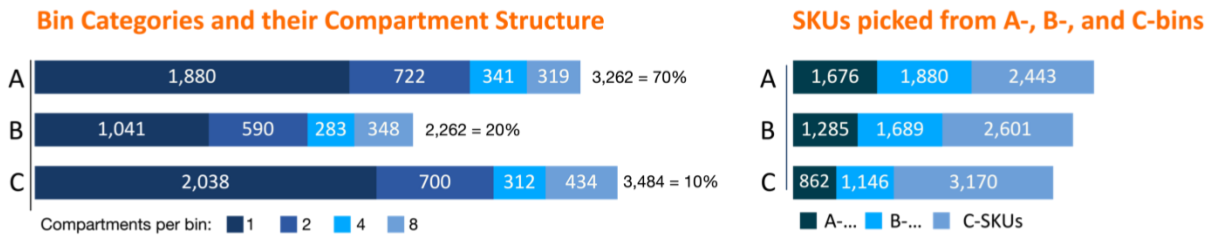

Fig. 4: Compartment structure of bins and SKU types by bin category

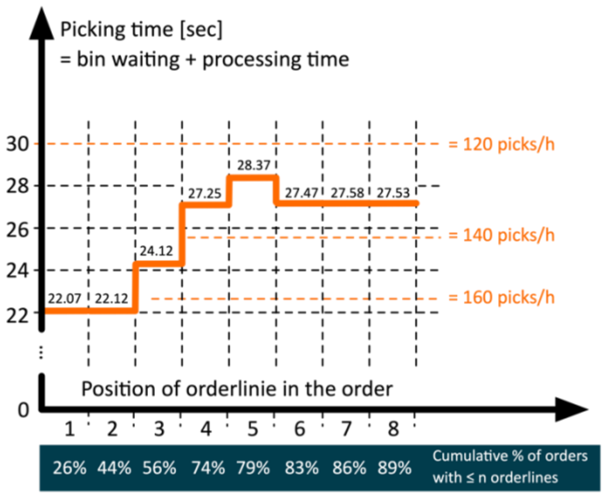

Fig. 5: Picking performance is poor for larger orders

The most important analysis to understand the performance of an AutoStore is therefore an ABC analysis. Since the wait time applies to bins, we perform the ABC analysis at the bin level, assuming that A-category bins represent 70% (B-category bins 20%, C-category bins 10%) of the bin presentations at picking ports. We then look at the compartment structure of the bin categories (**Fig. 4**, left-hand diagram). Of the 11,022 bins 9,008 have been presented to a port at least once in the study period. 3,262 of these are A-category bins, which is almost four times the number of the 876 top-grid positions. As a result, even A-category bins can only be retrieved from the stacks with considerable effort. **Fig. 4** (right-hand diagram) also shows that many bins are A-category bins not because of overwhelming demand for a single A-SKU, but because of cumulative demand for B- and C-SKUs.

If there were many robots working on the grid and enough time to prepare the order lines, this could still lead to good performance. Under the given boundary conditions (24 robots, 72.5 % of the order lines received during the day for immediate picking, **Fig. 2**), however, this is impossible, as the Pareto distribution is unfavorable for a cube storage system. If we had enough resources (time, robots) to prepare the order lines, we could expect the bin waiting time to be independent of the position of the order line within the order. **Fig. 5** shows that only for the first two order lines of an order the picking time (waiting time and processing time) is constant at around 22 seconds, which would mean an average of 160 order lines per hour and port. Each additional order line requires more preparation time, and the total output is only just over 130 order lines per hour and port. 56% of orders have three or more order lines and suffer from longer waiting times than expected (**Fig. 5**).

Further analysis shows that the AutoStore can work with an average inventory of only 250 order lines at any given time. With the current performance (five ports with a total output of 650 order lines), the average order line inventory is only enough for less than 25 minutes of operation. The AutoStore literally lives “from hand to mouth”. Such a small order line inventory forces the AutoStore system to start orders at the picking ports even though they have not been properly prepared. Picking performance is therefore destroyed if a bin has to be dug out from a lower position in a stack while the corresponding order is already being processed at a port.

So far, data provided by the WMS and the middleware has been used for the analysis. The data sets created by the AutoStore controller cannot be accessed because they are the property of AutoStore and not of the company operating an AutoStore. At the end of 2022, AutoStore announced UnifyAnalytics™, a data service that companies can purchase to visualize the performance of their AutoStore installation. UnifyAnalytics offers two versions: (1) a web application with predefined analytics that can be parameterized to break down data to a specific port and/or timeframe, and (2) an API with websockets that allows users to define their own analytics. During our study, some features of UnifyAnalytics were still under development. UnifyAnalytics does not grant access to granular data (robot movements to prepare and process an order line), but to aggregated data (5-minute intervals). Although performance problems are also visible in UnifyAnalytics, the aggregation to approx. 15 order lines is obviously a weak point. In addition, UnifyAnalytics cannot relate the performance analytics to SKUs because the controller does not know which SKUs are in which bins.

AutoStore sells its automated cube storage systems via distributors. Distributors are responsible for pre-sales advice, including simulation studies to find a profitable configuration (e.g., number of ports and robots). In addition to sizing an AutoStore, they also provide the middleware or at least have contractors who can provide this crucial piece of software that connects the WMS to the AutoStore controller and provides the user interface for the pickers. In the pre-sales phase, the distributor calculated a performance of 180 order lines per hour and port with even fewer than the 24 robots that are now in operation. The AutoStore system falls considerably short of this target and main reason for that is that the impact of dividing bins into compartments was neither addressed when sizing the system nor does the middleware allow to control the ABC characteristics of bins.

FINDINGS

The systems approach taken in analyzing the AutoStore system in the case company reveals a variety of factors influencing its performance that allow for generalization and can help explain different performance numbers in other installations. Some of the influencing factors relate to the system design and capacity determined in the planning phase of the installation, while others relate to operational aspects.

AutoStore's planning process includes an assessment of throughput (in order lines per hour), order structure (composition of orders, order lines and quantities), the shape of the Pareto distribution of order lines (as multi-deep storage systems such as AutoStore benefit from steeper distributions) and the expected speed of operators at the picking stations. The use of subdivided storage bins requires a change in the unit of ABC analysis from order lines to storage bins, where each bin represents the sum of all order lines combined in that bin. Only with the correct unit of analysis can an ABC analysis provide information about the expected retrieval performance and thus enable the system to be dimensioned accordingly in terms of storage depth, grid area and number of robots. Converting to subdivided bins at a late stage in the planning process or even during operation of the system can jeopardize retrieval performance.

Furthermore, there is considerable uncertainty in the interpretation of the ABC analyses. The evaluation of the slope of the Pareto curve as a result of an ABC analysis can be quite subjective. The use of objective measures of the shape of the distribution, such as the Gini coefficient, is not widespread. Furthermore, the distribution changes depending on the length of the period covered by the analysis. Longer observation periods lead to steeper distributions than shorter periods, which exacerbates the lack of objective comparability. At the same time, longer observation periods make it more likely that seasonal effects or past sales promotions are included in the data, which influences the results of the ABC analysis and reduces its informative value.

We distinguish between tactical and operational levers to improve the performance of the AutoStore system. Operational levers can be used by store managers at runtime, while tactical levers require investment and/or time. At the tactical level, the company could buy more robots as long as the grid size still allows for more robot traffic. However, it would be much better to address the underlying problem. The decision to use storage bins with compartments goes hand in hand with the need to control the combination of SKUs in the storage bins. The combination is not a one-time decision but must be maintained or intentionally rearranged during operation. Currently, the middleware does not support to request a specific bin type (e.g. a C-category bin) in the putaway process. Instead, the user can only request a bin with a certain number of compartments, which only reflects the space requirements of the goods, but not their ABC characteristics. The user has no way of understanding how adding a specific SKU to that bin changes the ABC classification of the bin. Companies planning to subdivide storage bins into compartments should (1) discuss the impact of this decision on AutoStore sizing with the distributor in pre-sales studies and (2) pay close attention to middleware design.

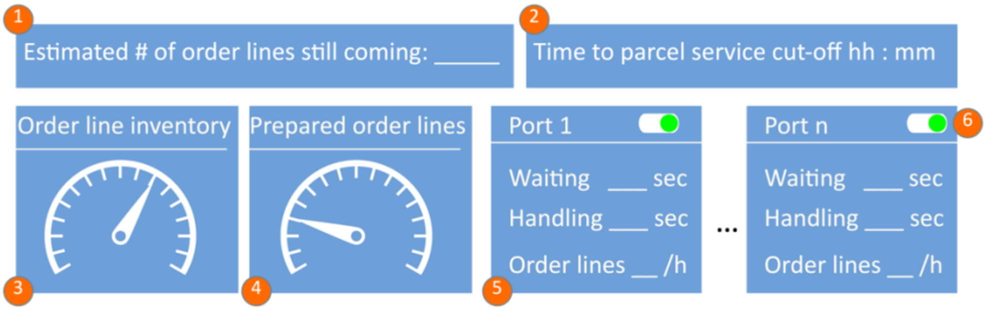

Fig. 6: Dashboard

The only operational lever available to the warehouse manager is the decision to close or open a picking port. At first glance, closing a port seems counterproductive. However, since each port ties up robots for bringing and removing bins, closing a port adds some robots that can help prepare bins for the remaining picking ports. While this action can reduce the waiting time at the remaining ports, it is clearly limited by the combination of the (unknown) number of order lines that need to be picked before the parcel service cut-off time and the (expected) productivity of the remaining ports. This is where the UnifyAnalytics data service can make a difference. The dashboard (**Fig. 6**) shows the expected number of order lines (1) that will arrive before the parcel service's cut-off time (2). UnifyAnalytics provides the order line inventory (3) and the prepared order lines (4). The (aggregated) live data, which arrives in five-minute intervals, can be used to summarize the performance of each port in the last hour (5): average waiting and handling time, picked order lines per port. Based on this information, warehouse managers can make better-informed decisions (6).

CONCLUSION AND OUTLOOK

The case study has shown that the implementation and operation of an RCSRS such as AutoStore benefits from a systems theory perspective that brings together parameters of the system, the information processing and the logistical and business context (**Fig. 1**). It is important to consider all these system elements thoroughly during planning and dimensioning. Like other automated systems, AutoStore has limited ability to improve performance at runtime. However, with the help of a live data service and dashboard, warehouse managers can gain at least some control.

As the literature review has shown, most of the published research papers focus on algorithmic improvements for RCSRS. To extend the system theory approach proposed in this paper, future research should systematically analyze the logistical and business environments in which the systems operate and aim at a detailed system classification, since the performance of RCSRS highly depends on how well it fits into this environment. Based on this classification, systematic performance analysis and customer satisfaction studies can help guide distributors and warehouse operators alike.

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Contextualizing Digital Capabilities in South American SME Operations: Reviewing Maturity Assessments considering Regional and Cultural Characteristics

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INTRODUCTION

In the light of developments such as the COVID pandemic, wars and geopolitical change, designing and managing global supply chains (GSCs) has become an ever more fundamental aspect of today's business operations (Shih, 2020). Amongst the long-term drivers for GSC is the global competitiveness of their underlying businesses. Companies are, amongst other factors, aiming to leverage location advantages such as price levels for products and labour. This extends to raw materials, especially those with a high relevance for industrialized regions such as the EU (e.g., critical raw materials act; EC, 2023). At the same time, digital capabilities are becoming increasingly important for the efficiency of GSCs. Technological advancements, such as artificial intelligence and big data analytics, have the potential to enhance GSC performance e.g., through improved forecasting accuracy and streamlined communication within the supply network. To optimize the advantages of technology, companies must possess comprehensive knowledge of their operations and effectively apply digital solutions to enhance their supply chain capabilities. This necessitates both organizational and individual expertise.

In 2021 Latin America and the Caribbean were the fifth-largest export partners of the world and therefore an important part of GSC (WITS, 2023). In Chile, amongst the leading economies in the region, digital topics are also gaining politically attention while strategic challenges for the public sector digital transformation become apparent (OECD, 2019). However, it remains a challenge to accurately assess the degree of digital maturity particularly of SMEs, which would help those businesses to improve their digital capabilities and hence increase their ability to participate in GSCs. This challenge increases when digital maturity models (DMMs) and respective assessment developed for western/industrialized countries are applied in different regions because cultural values play a pivotal, indirect role in influencing the adoption of technology-based services. This influence is channelled through individuals' attitudes towards technology (Cruz-Cárdenas *et al.*, 2019).

Digital transformation has become a pivotal aspect of Small and Medium-sized Enterprises (SMEs) worldwide, with unique challenges and opportunities arising in diverse regional and cultural contexts (Liu, 2023; Rupeika-Apoga and Petrovska, 2022). This paper aims to contribute to the understanding of digital logistics/service operations capabilities in South American SMEs by undertaking a comparative analysis of DMMs and a preliminary validation of an adjusted maturity assessment tool. Emphasizing the contextualization of preliminary findings, this study explores how regional and cultural characteristics shape the digital operations landscape for SMEs in South America.

The outlined circumstances underline the importance of well-functioning GSCs also from a digital perspective and motivate a better understanding of how to assess digital maturity in developing countries. Therefore, this study asks a) whether existing DMMs and respective assessments (need to) consider regional and cultural differences and b) whether they are a helpful tool to facilitate the digital transformation of SMEs in a country like Chile. Based on a brief literature review, an existing DMA tool was adjusted and preliminary applied at three SMEs in Chile. The findings reveal insights on challenges with the tool and in the region. The discussion outlines implications for how to better assess and improve digital capabilities in the region. The paper concludes with an outlook on future work.

LITERATURE REVIEW

Digital Maturity Models and Assessments

Maturity signifies the culmination of progress in a system's development. Systems, such as organizations, enhance their capabilities over time, moving closer to the realization of a desirable future state (Lahrmann *et al.*, 2011). Despite the existence of various terms, this paper opts for the term "digital maturity model" (Williams *et al.*, 2019). A maturity model offers guidance for organizations navigating their transformation journey, showing common paths to follow during this process (Berghaus and Back, 2016). This paper aims to present initial dimensions of a DMM tailored for SMEs, serving as a valuable evaluation tool for their digital transformation efforts (Wiesner *et al.*, 2018).

Based in DMMs, tools are developed to assess digital maturity. These so-called digital maturity assessments (DMAs) usually use questionnaires to address a varying number of dimensions considered relevant by the DMM (Williams *et al.*, 2019). The DMA is an effective tool for evaluating an organization's stage of digital transformation by examining the current use of digital technologies in various business functions, for example in the areas of employees, organization and strategy, and their adaptability (Kane, 2017; Sebastian *et al.*, 2020). Utilizing DMA is beneficial for SMEs, as it helps them develop appropriate strategies for digital transformation by providing insight into their current state (Gubán *et al.*, 2023). While DMAs vary in their stages, dimensions, and implementation strategies, they share a similar structure regarding progression and the rationale behind each stage. A growing number of models has raised criticism regarding the respectively high variance in models, dimensions and questions (North *et al.*, 2020; Petzolt *et al.*, 2022). Such critiques identify different focal areas of DMMs or limited transparency on their theoretical foundation that also supports the impression of some arbitrariness in their development (North *et al.*, 2020).

South America’s Digital Landscape

The digital landscape covers the national and societal dimension in addition to the business perspective. In Latin America, SMEs make up 99.5% of businesses. SMEs in the region create 60% of the official employment opportunities and contribute for 25% of the overall production value (OECD, 2022). A study found that companies with annual revenues above $500 million show a significantly higher level of digital maturity than the rest of the companies in the region (EY, 2022). In comparison, in the EU-28 SMEs represent 99.8% of all businesses. Digitally active businesses tend to invest markedly more, while non-digital enterprises are less likely to plan for digital investments. Moreover, SMEs account for 66.4% of the overall employment and contribute for 56.8% of the EU 28 overall production value (EPRS, 2017).

Regarding the overall digital landscape, the situation in South America is diverse. On the one hand, the rural population dominates the regional structures with a share of 35% in 2022 year. This may be a significant factor when considering the level of digital maturity due to the lack of internet connectivity in these regions. On the other hand, a study from UNESCO showed that governments in Argentina, Ecuador, Mexico, and Columbia started initiatives on improved digital culture (Kulesz, 2017). Nevertheless, the countries of South America are behind the more industrialized countries; in the year 2022 they ranked in the last positions of the IMD World Digital Competitiveness Ranking (IMD, 2022).

Regional and Cultural Dynamics in Digital Maturity Models

This section takes a closer look at the regional and cultural differences and their relevance for DMMs. According to the World Bank, Chile's economy recorded a GDP of USD 301.03 billion in 2022. To compare this with industrialized countries, Germany has a GDP of 4.07 trillion USD (World Bank, 2023). Looking at the unemployment rates, Chile registered a rate of 7.8% and Germany a rate of 3.0% of total labour force in 2022. Noteworthy, the unemployment rates are not easily comparable as they may include ‘formal’ and ‘informal’ employment, and the latter can achieve significant numbers, for example in Ecuador the informal sector employs more than 50% of the employed population (UN CEPAL, 2023).

As indicated above, maturity models cover different dimensions which the inventor finds suitable to determine the level of digital maturity. One of those dimensions is the technology used by a company (North *et al.*, 2020; Martin and Shar, 2016). Less developed countries or companies often lack access to the latest technologies. Therefore, it is essential to explore innovative technologies that support digital maturity. According to the IMD World Competitiveness Center, Chile's digital competitiveness was ranked at 41st. In 2022, the country recorded weaknesses mainly in the area of knowledge (see below) but also in the area of technology (IMD, 2022). Thus, assuming the utilization of identical technological tools should be avoided when constructing a DMA.

Additionally, considering employee support, the models examine training and competence for effective use of digital technologies (Mittelstand 4.0-Kompetenzzentrum Bremen, 2021). Cultural differences affect learning, tech adoption, and skill development. Adapting to these nuances is crucial for addressing employee dimensions in presented models (Pokharel, 2023). Chile shows weaknesses especially in 'knowledge' (50^{th} out of 63 countries); the subfactors 'training & education' and 'scientific concentration' are particularly relevant (IMD, 2022). In addition to learning and training, Busco *et al.* (2023) identify three conservative factors in Chilean work culture that should also be considered in terms of determining digital maturity in Chile; namely, a) the belief that change is only possible if it comes from the strategic top of management, b) a hierarchical work culture that prevents collaborative work, and c) a rejection of disruptive change. Hence, questions may have to be changed to draw conclusions about the digital maturity of a company.

Previous research has recognized the correlation between cultural norms and values and the behaviours associated with technology adoption (Srite and Karahanna, 2006). To understand the impact of culture on technology adoption, it's crucial to identify and comprehend both relevant cultural aspects and the perception of DMA questions; for instance based on the frameworks of Hofstede *et al.* (2010), which is extensively utilized to enhance intercultural interaction in business, and Trompenaars and Hampden-Turner (2012), who also discovered that individuals from diverse cultures exhibit distinct dissimilarities follow particular and foreseeable patterns. Noteworthy, individualism-collectivism (e.g., Hofstede, 2001) is amongst the most commonly employed cultural dimension in cross-cultural research. In cultures prioritizing group harmony over individualism, straightforward and assertive questions may be perceived as actions that could potentially damage one's social standing or reputation (Merriti and Helmreich, 1996).

Due to the influence of regional and cultural challenges on the successful utilization of business tools in different environments, such should be considered when assessing digital maturity in South America based on a framework developed in/for industrialized countries. Adjustments may be necessary, for example, regarding the assessed factors and weighting applied. Some of which are more obvious from the start while others may only surface once applying the tool.

METHODOLOGY

The research methodology follows a qualitative approach. The authors reviewed and amended an existing DMA developed by the Mittelstand 4.0-Kompetenzzentrum Bremen, which has been designed to assess the digital maturity of German SMEs. Thereby, the authors were able to focus on a more detailed analysis of the model instead of developing yet again another model, which is a criticism the authors consider valid to-date (see literature section). The authors focussed on potential limitations by comparing the model with existing solutions (such as Industry 4.0 readiness model, DIGIROW, etc.). This comparison led to the amendment of the model mainly by integrating the process domain. Due to the focus on SMEs, the process domain is particularly relevant because the understanding and proper management of business and logistics processes – even before digitalization – is crucial for business success and eventually for growth. The questionnaire used by the authors is hence designed to capture five dimensions: Strategy and Organization, Employees, Technologies, Services, and Processes.

In an exploratory approach, the authors applied their assessment tool at three SMEs via in-depth interview; in one case extended to a focus group with experts from a regional development body. Among the participants are a family-owned business for equipment rentals in the mining sector, a small importer and forwarding agent business, and a wellness studio representing a departure from the other rather traditional businesses; however, due to the owner's experience in establishing digital tools, her involvement in the focus group of Fortalece PYME Tarapacá adds a distinctive layer to the study. Based on the literature review, the authors leverage preliminary findings from these interviews.

Furthermore, the authors compared the DMA by the Fundación País Digital and the Inter-American Development Bank (IDB) used in Chile, the so-called "Chequeo Digital" (Henriquez, 2021), and discussed findings on regional and cultural characteristics with the focus group. Acknowledging the role of the Chequeo Digital for DMA in the region, this study, constrained in access to the Chequeo Digital, marks a deliberate departure with the intention to constitute an addition to the discourse on DMA.

RESULTS: REVISED ASSESSMENT TOOL AND INTERVIEWS

The analysis including the comparison with the Chequeo Digital allows for the identification of patterns, disparities, and areas where existing tools may require adaptation. The analysis centres on preliminary evaluating the amended DMA within the specific context based on three interview-led assessments. The study pays particular attention to regional and cultural influences that shape digital capabilities in SME operations.

The DMA tool and Chequeo Digital

The DMA used here is based on the maturity test by the Mittelstand 4.0-Kompetenzzentrum Bremen, which follows the approach of different weighting of various questions (Figure 1). The questions apply to five different dimensions of the SME (see Methodology section). The inclusion of the Processes dimension in the model adjusted by the authors sets it apart from the Bremen model. Each dimension allows for the examination of various questions using an evaluation scale. The responses are subsequently integrated into the overall result of the dimension evaluation, with specific weightings assigned. The DMA yields a rapid evaluation of the company's digital maturity level, spanning four tiers from "Iron/inexperienced" to "Gold/expert," within each of the five dimensions.

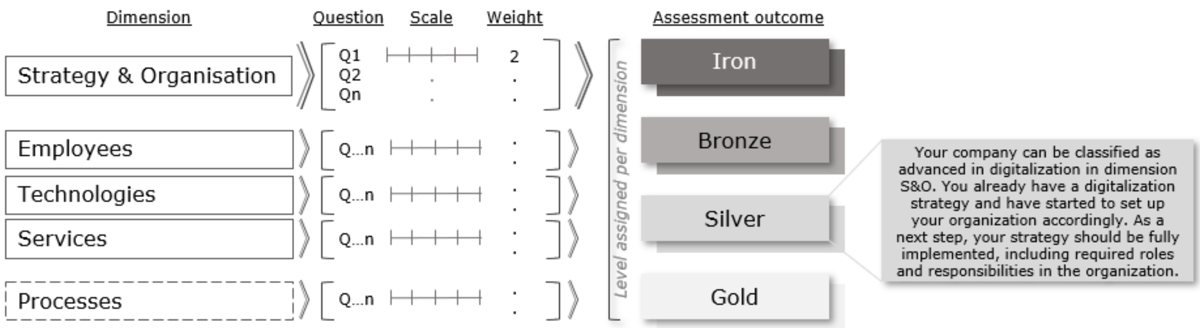

Figure 1: Schema of the DMA used in the study based on the maturity test by the Mittelstand 4.0-Kompetenzzentrum Bremen (2021)

A preliminary analysis indicates both consistencies and disparities between existing assessment tools. While certain dimensions align closely between the tools, others reveal potential challenges as well as unique approaches to digitalization relevant to the South

American SME landscape. The validation process sheds light on the effectiveness of existing tools and identifies areas where customization may be necessary.

Table 10 provides examples on how the adjusted DMA tool takes a distinct approach by adopting a strategic view, focusing on the higher-level perspective of the organization's digitalization strategy rather than the specific operational details (no. 1). Unlike Chequeo, which scrutinizes individual employees, the developed DMA looks at a broader perspective, delving into the entirety of SMEs to grasp a comprehensive understanding (no. 2). Emphasizing strategic relevance, the DMA tools used here sheds light on the crucial role of digital maturity measures, recognizing their impact on the overall success of SMEs. In contrast to Chequeo's focus on individual components, this study is more concerned with the overall digital direction and objectives of an entity.

No.	Questions Chequeo	Questions DMA
1	In the SME where you work, are there people dedicated to implement strategies based on new technologies?	Has the implementation of your digitalization strategy already been successfully initiated?
2	In the SME where you work, do you use cell phones, tablets or computers to work?	Are the following digitalization technologies fully implemented in your company?: Mobile devices; or use of mobile phone as well as laptops and tablets in daily tasks.

Table 10: Differences between Chequeo Digital and DMA

A crucial limitation for the authors is the limited availability of information around the model behind the Chequeo Digital. The authors were able to access the Chequeo Digital yet there is no information about how the individual answers influence the assessment results. For example, in many models, answers are weighted due to their relevance for a particular domain (e.g. processes) and the impact on digital capabilities. Therefore, it is important to know whether answers are weighted, and if so, how; this is furthermore crucial for the interpretation of the results since the used model applies a weighting scheme.

Findings and Relation to Literature

For the comparative analysis, three Chilean service-related businesses from different domains were assessed: mining, freight forwarding, and wellness. The mining equipment rental business displays a good understanding of digitalization's importance in strategy and organization supported by the respective score of 70%. Still a good level is reached in the technology domain with 58%, yet they scored lower in other domains. The interviewee showed a good understanding of digitalization potentials and the responses indicated that, despite some discrepancies, the company aims for a structured approach to digitalization. The interview provided the impression that although not all potential is essentially seen by the company, the discussion and questions showed a good understanding around the potential of digitalization for the overall business success. Furthermore, the case shows that the mining industry is driving digitalization beyond its core supply chain, as can be expected due to the sectors economic relevance for Chile.

The importer and forwarding agent's assessment reveals mixed results, with discrepancies between CEO assessments and on-site observations. The scores are overall better than at the rental business scoring higher than 50% (i.e., in the 'silver' range) except for the services domain with the highest score in the domain of employees (73%). Noteworthy, the strategy and organization domain as well as technology score lower with 64 % and 63 %, respectively. The case highlights the limited understanding of digitalization's potential and the CEO's role as the main driver. Thereby, some interviewee statements contradict part of the positive assessment outcomes. For example, on-site observations, despite the obvious use of digital technologies, indicated that the understanding of such seemed limited (e.g., the uses of selected odoo apps such as warehouse management and CRM are considered "an ERP system").

The outcomes from the wellness business showed lower overall scores (highest in services at 50%), with the interviewed owner demonstrating a realistic assessment, especially by pointing out existing limitations. The focus on customer relationship management and marketing in the digital domain revealed limitations in core business processes' digitalization potential. Although not providing specific insights on logistics, this case revealed that digital maturity may not only be limited by users such as employees nor by the availability of solutions but also by their perception and acceptance of such by the clients (as users). One example given is the use of online appointment bookings which are handled via WhatsApp since customers don't rely on more anonymous bookings, e.g., via a platform and would contact the business for confirmation regardless.

The latter assessment was accompanied by the focus group of experts from Fortalece PYME in the region of Tarapacá (northern Chile) revealing additional insights and confirming some observations made previously. At the level of the questionnaire itself, the experts suggested that some questions should be asked at various levels of granularity (e.g. on "paperless processes") to verify the answers. Similarly, the questions around ERP and other solutions require more detailed explanation since users in SMEs often consider partial solutions for sales/CRM as "ERP." This extends to the understanding of 'automation.' Namely the challenge that interviewees usually consider the use of a software solution, for example a CRM solution, as "automation" or "automated" yet they have no automated process in place. This observation from the interviews was confirmed by the experts.

From the cultural perspective, the interviews indicated a desire for a favourable assessment score, and hierarchy played a significant role in digitalization initiatives. The focus group confirmed these perceptions, particularly the first one as this has been a known challenge with the Chequeo Digital. Therefore, in the consultation with SMEs the experts only consider DMA results where they were present during the self-assessment.

The interviews, yet to different degrees, showed the importance of hierarchy in the development of digitalization (strategies). Digitalization initiatives seem to be driven by management and ideas are not emerging from the lower ranked employees. While this may be linked to the level of education on digitalization, the interviews showed that the CEOs/ founders consider themselves the only ones responsible including for the digital transformation. This aligns with literature indicting that authority and hierarchy may potentially affect the answers of the surveyed employees (e.g., Hofstede, 2001; Trompenaars and Hampden-Turner, 2012). Accordingly, the focus group discussed the need for cultural change to overcome hierarchical thinking hindering digital maturity. Moreover, the degree of uncertainty avoidance, which is high for Chile, seems to relate to rank as source of ideas. This implies a need for strict rules and typically relates to reliance on leaders (Hofstede Insights Oy, n.d.). Uncertainty avoidance also influences technology acceptance; hence the social environment should be carefully considered in cultures characterized with high uncertainty avoidance (Srite and Karahanna, 2006).

DISCUSSION: ASSESSING DIGITAL CAPABILITIES IN SOUTH AMERICAN SMEs

The presented results underscore the intricate relationship between DMMs, regional dynamics, and cultural nuances in the context of SMEs in South America. The discussion seeks to integrate insights gleaned from three diverse cases—mining equipment rental, freight forwarding, and wellness—and examines how these findings contribute to the understanding of digital operations in the region.

The family-owned mining equipment rental business provides valuable sector-specific insights from one of the most important industries to Chile's economy. The mining industry operates globally, which drives suppliers to adopt new digital technologies to improve their competitiveness. The COVID pandemic increased the need for technological and cultural adjustments. The respondent's good knowledge around digital capabilities and their potential for business success reflects these circumstances. The case indicates a more flexible organizational structure, which could help in the digital transformation. However, the company currently lacks a formal digital transformation plan. Therefore, without the C-level commitment, the intention to increase investment for digitalization is uncertain.

The importer and forwarding agent business contributes a perspective from the logistics and trade domain providing insights into the sector and how digitalization is perceived by owners/managers. In combination with comments indicating limited understanding for the potential of medium to long-term planning for digitalization (e.g., budget is used "when available" supposedly without the need for financial planning that could neither be detailed though was ranked "partially applies"), the case helps to understand some of the discrepancies between self-assessment and actual digitalization in the field. In addition, the interview reflected a desire to score high in the assessment.

The inclusion of a wellness studio, despite its departure from traditional SME sectors, offers a compelling dimension, with the owner's digital tool expertise providing nuanced insights. A more realistic assessment of the digital capabilities suggests that digital literacy at SMEs can be improved by projects such as Fortalece PYME. However, the case also demonstrates that cultural aspects can hinder technology uptake by consumers. Due to the owner's experience in establishing digital tools, its involvement in the focus group of Fortalece PYME adds a distinctive layer to the study, providing insights into digital maturity across diverse SME categories.

The role of hierarchy in driving digital strategies, the desire for favourable assessment scores, and the need for cultural change emerge as critical considerations for enhancing digital maturity in SMEs. This emphasizes the need for region-specific adaptations in DMAs, considering cultural nuances. This integrated perspective paves the way for refining DMMs and respective DMAs, ensuring their applicability in diverse contexts.

The findings from interviews and the focus group accentuates the cultural and hierarchical dimensions shaping digitalization initiatives in Chile. This is relevant for asking questions (who asks whom) and for the evaluation (who/what management level was interviewed). In this study, CEOs answered questions in the small businesses while middle management answered in the case of the rental business. Although one cannot draw general conclusions from this small sample, the relevance of hierarchy should be considered when applying these models and tools.

Further, the findings suggest that some of the assessment questions require revision, mainly in the domains of technologies (identifying relevant ones, providing better explanations to address limitations in perception), processes (to identify root-causes for limited digital capabilities), and culture and employees (role definition). The questions of the Chequeo Digital exemplify how the DMA tool can benefit from more granular questions; yet responses must be combined and clustered, e.g. around software used by individuals, to establish a better understanding whether solutions are integrated across processes. This would also reduce the need to have a consultant attend the questionnaire.

The findings, regarding both the digital maturity itself and the regional and cultural characteristics, implicate the need for teaching and training in digital technologies and digital business models. The expert panel emphasized the importance of education in the region. The need for training is also in line with findings from other studies (see literature section). Reasons for this, amongst others, provide the different understanding of "automation" or "ERP" systems as well as the phrasing of questions and the role of hierarchy as part of the (company) culture. The authors suggest concepts such as smart factory competence centres, comparable to German "Mittelstand-Digital Zentren," to support the overall digital understanding. Such environments may as well contribute to new perspectives on the role of employees in digital transformation.

While this study provides valuable insights, it is important to acknowledge its limitations. Most notably are the sample size, which is small and not representative for all SMEs, and constrained access to the Chequeo Digital, which limited the author's ability to assess the tool at a more detailed level (e.g., weightings). More data both from SMEs and from other

DMAs would further enhance the analysis. Furthermore, as the study aimed to collect preliminary data, a revised version of the DMA would need to be texted with local SMEs. Lastly, the analysis of cultural factors influencing digital maturity is limited to the DMA as a tool, however, preliminary findings related to the cultural dimensions would motivate a more detailed analysis of such in their relation to digital maturity and technology adoption.

CONCLUSION

The study addressed the challenges in assessing the digital maturity of SMEs in Chile, a developing country, when using DMMs developed in industrialized contexts. The findings highlight the multifaceted dynamics at play in the digitalization landscape in Chile and the need to involve SMEs in global SCs. Examining differences between Chequeo Digital and the DMA used, adds depth to the findings. The exploration of individual case assessments sheds light on varied digital maturity levels, influenced by industry specifics, CEO-driven initiatives, and cultural perceptions. The findings underscore the need for region-specific adaptations in DMAs, recognizing the diverse characteristics of SMEs across sectors.

The digital transformation of SMEs in South America is influenced by the regional and cultural context, as demonstrated by the adaptation and application of a DMA tool to three Chilean SMEs. Tools used should adequately reflect such influences to increase their effectiveness. Further, the study highlighted that both cultural values and the perception of change affect the adoption of digital technologies and that of DMAs. Eventually, a need for training and learning is evident that allow exploring and experiencing digital technologies first-hand. This can facilitate the adoption of digital tools among SMEs, which is crucial for their development and competitiveness in increasingly digital global SCs.

The study suggests an integrative approach to improving the digital capabilities of South American SMEs. This requires continuous training, digital literate management, and the development of a coherent digital strategy subject to company specificities and its cultural context. Such approach aims not only to increase the digital maturity of SMEs, but also to ensure that the transformation is sustainable in the long term. In this context, DMAs are among the possible tools to consider. In essence, the study underscores the importance of context-aware DMAs and advocates for proactive measures to empower SMEs in navigating their digital transformation journey. To support this development, the authors aim to revise their DMA questions and test the revised version in the future in South America.

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Supply Chain Analytics

Enhancing Supply Chain Risk Identification: Analyzing the Impact of LLM Parameters for precise Classification

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Abstract:
This study investigates the impact of Large Language Model (LLM) parameters, specifically temperature and top P, on Supply Chain Risk Detection (SCRD). With a heightened focus on Supply Chain Risk Management (SCRM) using AI, the research employs a Design of Experiments (DoE) approach. The results reveal optimal temperature values for valid assessments in SCRD applications. The study emphasizes the importance of tailored LLM parameter settings, contributing insights for future research and practical applications in enhancing supply chain resilience. Suggestions for incorporating Response Surface Methodology (RSM) and refining the process are proposed for further investigation.

Introduction:
In recent years, businesses have experienced and were exposed to numerous major events causing unplanned and unexpected disruptions within seemingly robust supply chains: the Covid-19 pandemic which contributed to health risks, workforce deficiencies, and substantial shifts in demand; or the conflict between Russia and Ukraine, exerting significant influence on procurement and sales dynamics, represent notable instances (Handfield et al., 2020). In addition, man-made events like the Ever Given Grounding or the damaged railway tunnel in Rastatt, Germany showed the strong influences within bottlenecks in transportation systems. Due to the nowadays globalized nature of many supply chains, the impacts of such events were felt on a world-wide scale (Gurtu & Johny, 2021). As a result, there has been a growing focus in both research and practical applications on Supply Chain Risk Management (SCRM) to enable identification, mitigation, and management of risks that could potentially affect a business's supply chain (Deiva Ganesh & Kalpana, 2022a). Here, the accuracy of risk identification plays a vital role as it is considered the basis and first step for subsequent risk mitigation and management (Deiva Ganesh & Kalpana, 2022b). In this context, the employment of artificial intelligence (AI) to cope with huge amounts of data is considered a key factor for success (Deiva Ganesh & Kalpana, 2022a). While first research exploring the integration of AI into risk identification and thus going beyond conventional approaches highlights first promising use cases, such as the prediction of uncertain events (e.g. Schroeder & Lodemann, 2021), continuous monitoring (e.g. Modgil et al., 2022), or extraction of unstructured data (e.g. Chu et al., 2020), the field of research is still considered underrepresented and is lacking formal approaches (Richey et al., 2023). Furthermore, in the realm of AI-based risk categorization utilizing Large Language Models (LLMs), prevailing research predominantly concentrates on classifying risks within overarching categories, such as environmental risks and financial risks (e.g., Chu et al., 2020). The utilization of LLMs for risk classification however, holds the potential to classify and thus identify individual supply chain risks in real-time based on extensive sources, such as social media or newspaper articles. This approach has the capacity to augment existing supply chain risk identification practices by offering a more granular and timely assessment.

In this regard, this paper aims to expand the current research landscape of AI-based risk identification through LLMs. As the output accuracy of LLMs is highly dependent on the individual use case and set parameters (e.g. temperature and top P), a detailed analysis of these determinants is imperative (Xu et al., 2022). This will be carried out in this paper to serve as foundation for further studies and the practical application. To reach the given objective, the paper is structured as follows: The next section overviews the research methodology, a Design of Experiments (DoE) approach, which is then operationalized, demonstrated, and evaluated based on sample data. Lastly a conclusion is, and directions for future research are given.

Methodology

As mentioned, the DoE approach as defined by Kleppmann (2020) is leveraged for a systematic exploration of the parameter space by varying LLM parameters in a controlled and structured manner. This systematic variation of parameters supports in efficiently allocating resources by minimizing the number of experiments to be performed while providing meaningful insights into parameter effects.

Through DoE, the impact of individual parameters and their interactions on classification precision for supply chain risk detection (SCRD) is analyzed on a quantitative basis. DoE aims for achieving a comprehensive understanding of the system under study, enhancing the reliability and robustness of the study results and potential allowing for the knowledge transfer to other application cases. Due to the missing research on the impact of LLM parameters in the light of the presented application in SCRD this approach has the potential to help resolve the knowledge gap and also to further the understanding regarding the impact of LLM-Parameters in other cases.

In Figure 1, the process of using DoE is outlined. As shown in the figure, the process starts by creating an understanding of the initial situation. This is essential to clearly define what knowledge is to be gained through the research. The research objectives can then be derived on this basis. Specific hypotheses may be drawn upon. These are to be placed in a targeted manner in the context of SCRD. The next step is to define how success can be measured in the present use case. As this is a field with substantial room for interpretation, this step is particularly relevant. In order to better understand the relationships between the input and target value(s) developed in the previous step, an analytical research plan is developed in step 4. This step concludes the planning part of the DoE process. This is followed by the implementation of the research. At this point, it should be noted that, in addition to the experiments presented in this work, a large number of other experiments are also conceivable. In the next step, the data is obtained by carrying out experiments and subsequently being analyzed. Based on this evaluation, the results are to be interpreted and measures are to be worked out as to how they can be translated back into practice and lead to added value. The effectiveness of these developed measures is then validated in the next step to ensure that it is not, for instance, an anomaly in the test data. Based on this reconciliation and validation, the data obtained via the process, as shown in the figure, can then be reintegrated back into the process and further investigations can be carried out on this new foundation.

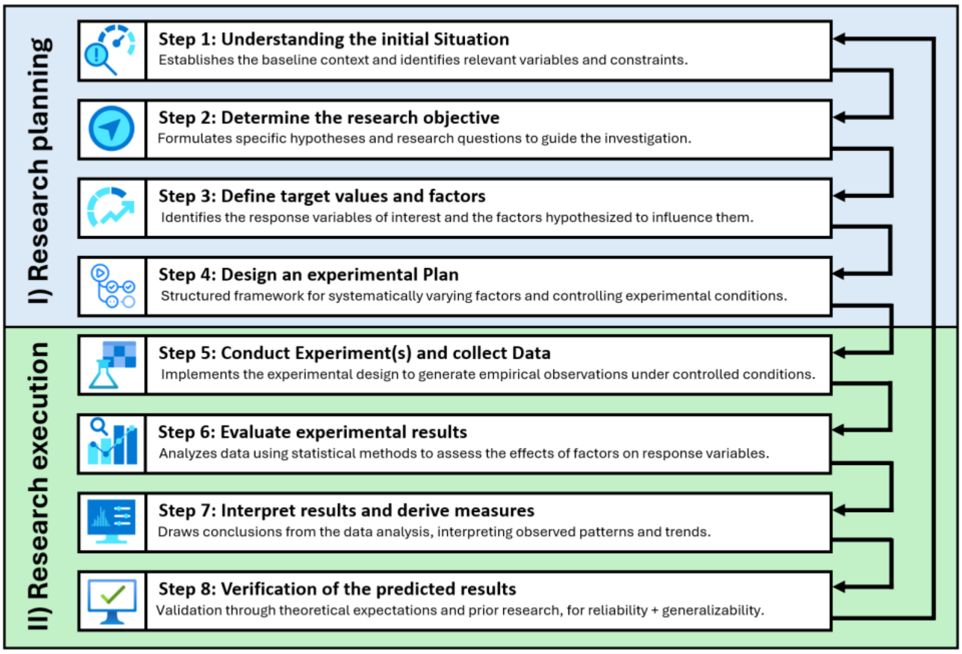

Figure 2: Application of the DoE-Concept

1. Understanding the initial situation

The present study is conducted within the overarching research project "WiReSt", scientifically driven by the FH Muenster. The project focuses on improving supply chain resilience through a robust early warning system (WESt mbH). Here, the utilization of novel technologies such as LLMs for real time risk classification represents a core part as it enables to acquire and process vast amounts of quantitative and qualitative data that could unveil latent risks in early stages. Previous studies within this research project have already outlined first concepts and an initial framework for AI-based real time global risk assessment into which the outcomes of the present study will be assimilated (Eschenbächer et al., 2023).

2. Determining the research objective

The aim of this study is to increase the knowledge on how to adjust LLM parameters for SCRD (in this case correct classification weather the content of a news article is to be assessed as critical or not). There are three modifiable elements in the overall process at the meta-level. These are the input itself (e.g. a news article in combination with a prompt), the set variables and the LLM itself. The objective of the study, to evaluate the parameters, emerges from the tabular representation of the two factors consistency and workability (in the context of this study) in Figure 2. These two conditions have to be met for an examination to be relevant in the context of this study.[1] The objective of this study therefore includes investigating the effects that modifications to the variables have on SCRD.

[1] It has to be noted that a customization/alignment of the LLM itself is also possible in theory. However, this is outside the application-oriented focus of this work.

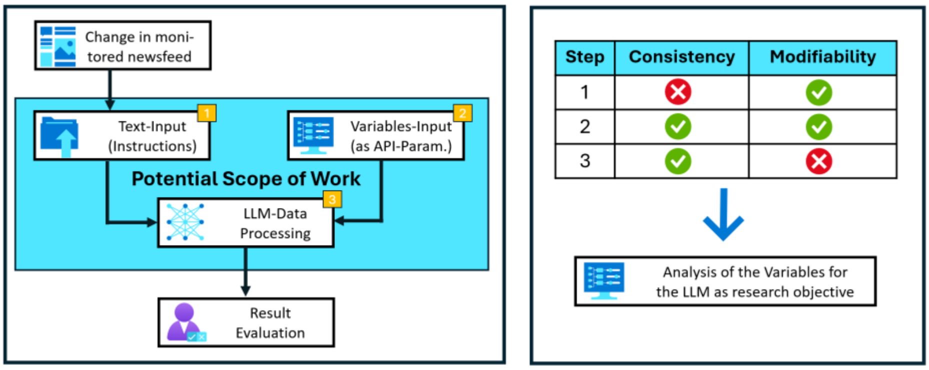

Figure 3: Determining the research objective based on the potential scope of work

3. Define target values and factors

Next, the target values and the factors with a potential impact on these values are to be determined. As highlighted in the chapter on the methodological approach, the definition of the target variable is of particular interest. How the target variable is assessed in the context of this study is shown on the right-hand side of Figure 3. In the first instance, a distinction is made between two categories based on the output of the LLM. Firstly, there are responses that are in the expected format (either "0" for a non-critical or "1" for a potentially critical event) or those that are not (other outputs, e.g. words or other numbers). If the response is in the expected format, the correspondence with the target evaluation of the corresponding information is to be assessed as shown in Figure 3. For each article that is later used as input, the researchers assess whether it should be rated as critical or uncritical. This rating represents the value that the model should output.

In terms of factors, there are potentially seven parameters that could be examined as part of this study. To focus on the parameters with the greatest potential added value in the context of the use case at hand, a pre-selection was performed by the researchers. An exclusionary procedure was used, whereby variables that could be problematic in practical application were excluded and the remaining variables were further researched. The variables that are relevant to the research are marked with an "R" in the figure (Temperature and top P). The temperature parameter regulates the randomness of the model's output, with higher values promoting increased diversity in generated responses (La Vega, 2023). On the other hand, the top P parameter controls the probability of distribution of potential next tokens by considering only the most probable ones, based on their cumulative probability mass (La Vega, 2023). These parameters play a crucial role in shaping the coherence, diversity, and quality of language generation in LLMs, influencing their overall efficacy in various natural language processing tasks (La Vega, 2023). The model selection was excluded due to the frequent version changes in the LLMs made available. The parameters of maximum length, frequency penalty and presence penalty were excluded from the analysis due to the expected output. As the evaluation should be either "0" or "1", parameters that focus on the effect of values that have already been output are not expedient. Using the maximum length is not practicable due to the varying length of the input in the form of news articles. The use of the "best of..." parameter is potentially interesting, as various results are generated here and only the most suitable[2] result is output. However, this parameter is only available for legacy models.

[2] According to the documentation of OpenAI – However, there is no specification on how the selection is conducted

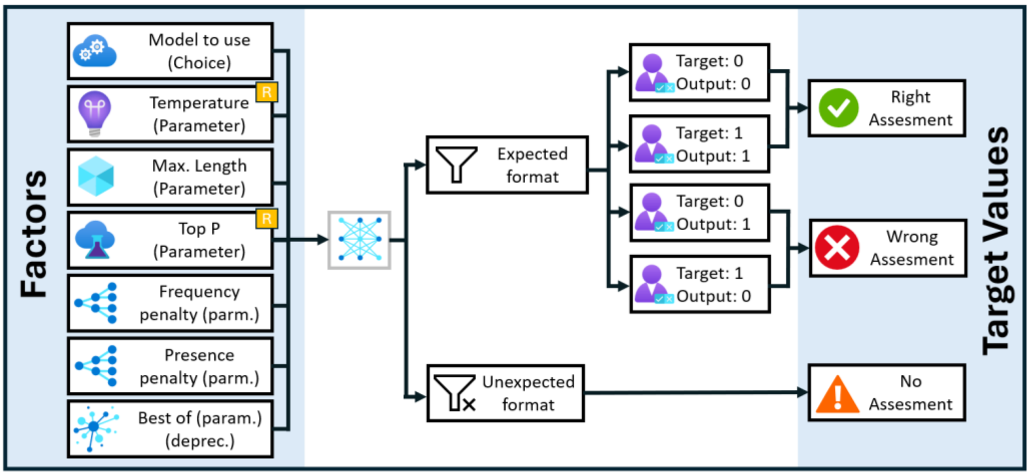

Figure 4: Definition of target values and factors
(Note: Target=0 equals an assessment as uncritical, 1 equals an assessment as critical)

4. Design of an experimental plan

The following diagram shows the experiment plan to be followed. The temperature parameter is changed first, ceteris paribus. This is due to the fact that it is likely to have a stronger influence on the results due to the direct impact on the next token; the results from this procedure are then subjected to analysis. Based on the potential optimum value determined from the analysis, the top P parameter is now adjusted ceteris paribus and the results are evaluated. In the third and final step, the effect of changing both parameters is to be examined based on the findings from test 1 and test 2. This is carried out using random samples to ensure stability of the previously determined optima.

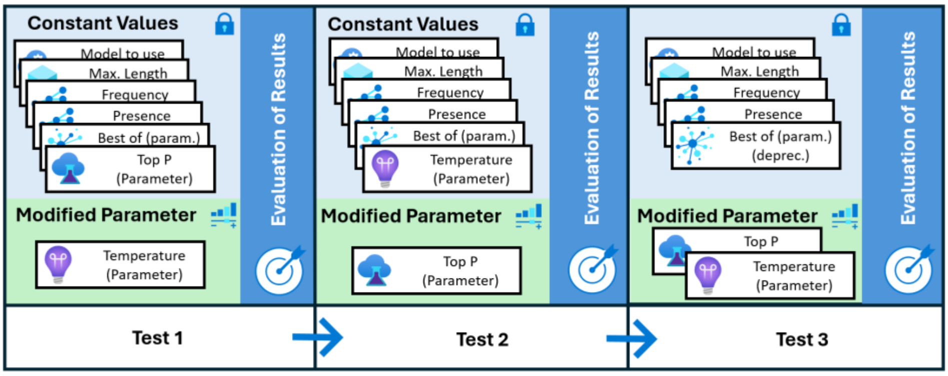

Figure 5: Experiment Plan

5. Conduct experiment(s) and collect data

To increase the reliability and validity of the findings, a large sample size is expedient, as, for instance, the temperature parameter inherently functions to amplify the randomness of responses with increasing values. 21 assessment objects are used, each of which occurs 41 times in each processing batch, to reduce the number of random effects. The examinations with a direct focus on the temperature parameter are carried out 5 times with the same values and the mean values are calculated. As depicted in Figure 5, the modifiable variables are stored directly in a Microsoft Excel table used for the study and the evaluation results are then automatically transferred back into this table so that the table can be evaluated.[3]

[3] Due to the operational nature of this step, no further details on operationalization are presented at this point. Both raw data and the configuration of the set-up for automated testing will be made available by the researchers on request.

Figure 6: Presentation of the operational process for test execution for large(r) scale automated testing

6. Evaluate experimental results

During this step, the data is analyzed. This is carried out using Microsoft PowerBI to enable automated evaluation of new data and analysis of individual effects in a large data set. The interim results are presented in the following sub-chapters.

6.1 Impact-Evaluation for the temperature parameter

The figure below shows the result for 5 tests carried out, each with 861 samples consisting of 21 questions in 0.05 increments for the temperature parameter in an interval of 0.00 - 2.00. The deviations show that the relative stability of the results begins to decrease for the range from a temperature value of 1.40 onwards. Optima in relation to desired results are present at both 0.25 and 0.60. Due to the greater distance to more unstable results, 0.25 is defined as the potential optimum value for the temperature parameter for fixed other variables.

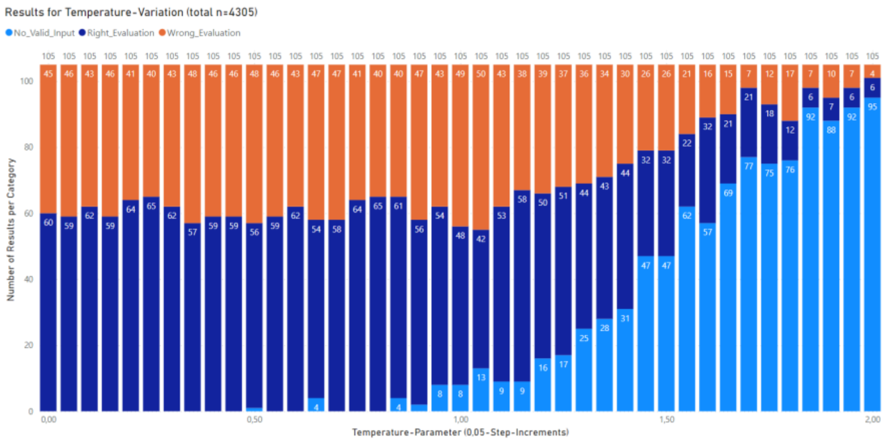

Figure 7: Evaluation of the data when adjusting the temperature parameter

Figure 7 shows an example of the data for the execution at two different prompts with variation of the temperature parameter in 5 test runs. This shows the high tendency of the LLM to output changing results measured against a deterministic output.

Figure 8: Exemplary presentation of the data for two data points to be evaluated

6.2 Impact-Evaluation for the Top P parameter

The influence of the top P parameter is evaluated in the same way as already described in section 6.1. The evaluation shows that there are no significant fluctuations in the results up to a threshold value of around 0.5 (see Figure 8). After the threshold value is exceeded, the fluctuation between correct and incorrect categorizations increases. There are no non-valid inputs. Due to the fluctuations in both positive and negative directions, no reliable optimum can be determined for the top P value at this point.

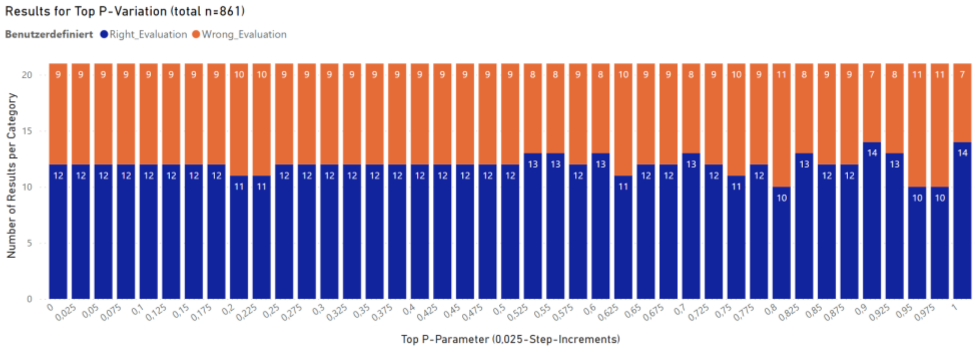

Figure 9: Results for top P-Variation (total n=861)

6.2 Impact-Evaluation for the temperature and top P parameter

In this case, the procedure is as described in 6.1 and 6.2. 41 combinations of random values in the ranges of 0.00 - 2.00 (temperature) and 0.00 - 1.00 (top P) are generated and fed into the process. The results are then used in a naive bayes model calculating weather the provided answer of the LLM is correct or incorrect for the subset of right or wrong predictions. Figure 9 shows that the optimal value for temperature to support in leading to a valid assessment by the LLM is at around 1.1., the biggest positive distinction from wrong prediction is until the lines intersect at approx. 0.8.

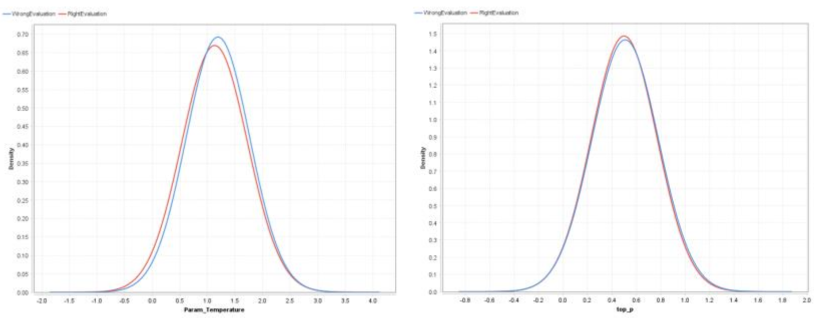

Figure 10: Results of naive bayes model to predict the model performance (note: target class (correct prediction) is shown in red)

7. Interpret results and derive measures

Based on the results from the evaluation of the investigations carried out, it can be assumed that an increase in the temperature parameter up to a value of 0.8 is expedient, provided that outputs that do not correspond to the expected format are excluded. Overall, the study shows that the temperature parameter achieves the best results with a value between 0.4-0.7 in the present example. An influence of the top P parameter on the results could not be determined.

8. Verification of the predicted results

In order to ensure that the results are not random due to the selection of test cases, a sample-based evaluation was carried out. No facts contrary to the results described in step 7 could be derived from the samples taken. The random samples were taken on an exploratory, manual basis.

Practical Implications

The implications derived from this study are twofold. Firstly, in relation to the specific use case. The study shows that correct parameterization is essential for adequate risk classification. The enormous degradation of the quality of the results, especially with a high temperature parameter, due to incomprehensible results, clearly shows the influence of the parameters on the quality of the evaluation. Conversely, an excessive reduction of the parameter can lead to more complex interdependencies being ignored in the present application. Secondly, implications can be derived regarding the general added value for working with LLMs. By evaluating the influence of the parameters on the present use case, conclusions can also be drawn for similar use cases. In addition, the framework and investigation process presented in this paper can also be applied to, and testes for other cases with varying question types. The DoE methodology is assessed as suitable for iteratively and systematically approaching the optimum parameters for each analyzed use case.

Conclusion

The aim of this research to increase the knowledge related to the impact of individual parameters and their interactions on classification precision for SCRD is to be considered achieved. By using the DoE process, a research design was set up in a structured manner via the selection of parameters, which enabled findings against the background of the present use case and led to new insights on the performance of LLMs for SCRD.

In a subsequent phase, it would be valuable to integrate Response Surface Methodology (RSM) with the outlined Design of Experiments (DoE) approach to refine the modeling of the correlation between input factors and the response variable(s). This integration aims to optimize the adjustment of Large Language Model (LLM) parameters for maximizing classification precision. The introduction of a second target parameter becomes essential, particularly in non-binary tasks, such as the classification of specific risks using the LLM. Employing statistical methods, including Analysis of Variance (ANOVA) and regression analysis, will be necessary to further scrutinize experimental data and derive a function for modeling the impact on prediction performance.

Another promising venue for further research lies in conceptually modifying the process. For example, it was noted during the evaluation of the results, that in some cases output such as "non critical: 0" was generated. By using a second LLM prompt to eliminate such cases, a potential misinterpretation of the output caused by deterministic filtering on the results could be reduced.

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Artificial Intelligence as Catalyst for Cyber Resilience in IoT Maritime Supply Chain

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1. Introduction

The Internet of Things (IoT) is increasingly being integrated into many spheres of society to improve the efficiency, safety, and visibility of operations. Overall, IoT technology is revolutionizing supply chains by providing unprecedented visibility, efficiency, and safety across all stages of the logistics process, from movement operations to wharehouse management to cargo handling. In the context of the maritime supply chain, IoT pertains to the network of interconnected devices, sensors, and systems deployed onboard vessels, at the ports, and throughout the maritime logistics process. The areas where IoT has been deployed in this sector include vessel monitoring and maintenance, cargo tracking and monitoring, port operations optimization, environmental monitoring and compliance, safety and security, ship visibility and collaboration, and predictive analytics and decision support for berthing. In what follows, we will briefly tour each of the areas where IoT has made an impact.

On vessel monitoring and maintenance, the IoT sensors installed onboard ships can monitor various operating parameters such as engine performance, fuel consumption, temperature, and equipment health in real-time. Capturing this data allows the ship operators to optimize vessel performance, schedule predictive maintenance, and prevent breakdowns, ultimately reducing unneceesary downtime and operational costs.

On cargo tracking and monitoring, the IoT devices attached to the cargo containers during transit enable the real-time tracking and monitoring of goods throughout the supply chain. This then provides stakeholders with visibility into the location, condition, and status of shipments, allowing for better inventory management, route optimization, and goods security during transit from plant to port.

On port operations optimization, the IoT sensors and smart infrastructure deployed at the ports now help to streamline operations such as container handling, berth scheduling, and customs clearance. Automated systems powered by IoT data have helped to improve port efficiency, reduce congestion and dwell time at the yard, and minimize berth turnaround times for vessels, leading to tighter dwell times and cost savings, and faster cargo churn.

As for environmental monitoring and compliance, IoT sensors can monitor environmental factors such as air and water quality, and noise levels in port areas and onboard vessels. Such reporting data facilitates speedier compliance with environmental regulations and helps to mitigate the adverse impact of maritime operations on marine ecosystems.

IoT-enabled surveillance cameras, access control systems, and perimeter sensors enhance security measures at ports and onboard vessels. Real-time monitoring and alerts enable rapid response to security threats such as piracy in open waters, unauthorized access, or safety incidents, ensuring the safety of personnel, cargo, and infrastructure.

Next, on supply chain visibility and collaboration, using IoT can now facilitate greater visibility and collaboration across the entire maritime supply chain ecosystem. By sharing real-time data on vessel movements, cargo status, and port operations, stakeholders such as Samsung SDS and Hyundai shipping can optimize their global logistics processes, better coordinate activities on land and sea, and respond quickly to any disruption or delay.

As for predictive analytics and decision support, IoT-generated data combined with advanced analytics and machine learning allow for appropriate predictive analytics and decision support capabilities. By analyzing the historical data and identifying key trends or data patterns, decision makers can anticipate potential issues, optimize their resource allocations, and make informed decisions to improve supply chain efficiency and resilience.

As IoT adoption continues to grow, the maritime industry stands to benefit from the enhanced competitiveness, sustainability, and resilience in an increasingly interconnected global economy. However, digital piracy has also taken place. There is now a call for greater resilience on the cyber front, as increasingly more maritime systems are reliant on cyber systems to support operations.

Our study treats a scenario study involving container transfer operations at a container terminal, where prime movers are instrumental in transporting containers between yard and berth. These operations entail transferring laden containers discharged from vessels at the berth in a dual cycle to designated areas, followed by the relocation of containers scheduled for loading onto vessels from their respective areas in the container yard to the appropriate berth, as quickly as possible. We highlight the vulnerabilities in the IoT systems introduced by the deployment of wireless communication networks using GPS trackers. Such IoT systems are critical for tracking the real-time location and movement of the prime movers in container terminals, particularly between the berth and yard. Thus, we investigate IoT-enhanced prime mover operations at container terminals.

The rest of the paper is set as follows. Section 2 presents the pertinent literature. Section 3 presents the relevant research method and offers a scenario study of IoT enhanced prime mover operations for analysis. Section 4 discusses the results. Section 5 offers some managerial insights. Section 6 concludes the paper.

2. Cyber Resilience in IOT Maritime Supply Chains

2.1 Related Terminology

Resilience is frequently characterized in the literature as the capability to anticipate, strategize for, endure, recuperate from, and adapt more proficiently to unfavorable occurrences (Kott and Linkov, 2019; Zemba et al., 2019). Cyber resilience refers to the capacity of an entity to withstand, react to, and recover from cyber events, thereby maintaining the entity's operational continuity (Hausken,2020).

To enhance the cyber-resilience of a system, it is imperative to be cognizant of the elements that must be considered when formulating a strategy for cybersecurity. Cybersecurity is typically viewed as an amalgamation of technologies, methods, and practices aimed at safeguarding networks, computers, programs, and data against unwarranted attacks, disruptions, or unauthorized access (Sarker et al., 2021). Table 1 details some of the known and documented incidents that have led to cyber risks.

Put Table 1: Forms of cybersecurity incidents here

Cyber risks, a fundamental consideration of cybersecurity, refer to the operational perils associated with information and technology assets, which pose substantial threats capable of compromising the confidentiality, availability, or integrity of information or information systems (Eling and Schnell, 2016). Research suggest that various cybersecurity incidents have the potential to inflict security risks within an organization's systems and networks, or impact a firm, encompassing a range of threats and vulnerabilities (Sun et al., 2018).

In contemporary academic discussions, cybersecurity is often associated with related concepts such as Information Security, Data Security, Network Security, and IoT Security (Al-Garadi et al., 2020).

IoT security, the central theme of our research, is significant in the field. IOT primarily involves safeguarding Internet-enabled devices, namely IoT devices, that operate within wireless network environments (Hassan, 2019). The key elements critical to the functionality of IoT systems include the connectivity of the networks and devices, device interoperability, data analysis, management of devices and networks, security measures, and data storage capabilities (Inayat et al., 2022). Shewale (2023) has projected that, by the end of 2023, there would be 3.5 billion cellular IoT connections. So, identifying and classifying the risks inherent in an IoT architecture is crucial for the development of cyber-resilient systems. Figure 1 shows the security aspects associated with IoT architecture.

Put Figure 1: IoT associated security infrastructure here

The challenges posed by the IoT security frameworks can be categorized into two domains: IoT attack surface and IoT vulnerability (Díaz López et al., 2018). Table 2 shows the sub-problem types for each domain.

Put Table 2: IoT security related problems by domain here

2.2 Cyber Resilience in Maritime IoT Applications

In the maritime supply chain, seaports are also increasingly adopting IoT technologies as part of their digitalization effort. This has led to various improvements in efficiency, safety, and environmental impact (Jović et al., 2022). With the need to transition to autonomous systems and smart ports, there is a current play of creating a network of smart sensors, data centers and wireless devices connected via IoT (Agatić and Kolanović, 2020). The future of IoT in ports is expected to eke out significant advancements and transformations including the real-time monitoring of berths, crane and yard equipment, and labor, optimizing resource allocation, and streamlining of cargo handling operations (Yau et al., 2020), integrating IoT with other technologies like AI, blockchain, and 5G connectivity (Chen et al., 2020), smart port initiatives, IoT sensors to assist in monitoring and analyzing adverse environmental factors, and ensuring compliance with regulations and minimizing the impact of maritime operations on the ecosystem (Koot, 2019).

As IoT proliferates, so too will IoT-related cybersecurity threats. The SonicWall Cyber Threat Report (2023) reports a 37% global increase in IoT malware during the first half of 2023, totaling some 77.9 million attacks, up from 57 million in the same period of 2022. As ports become more connected through IoT devices, they also become more vulnerable to cyberattacks, data breaches, and IoT vulnerabilities. As ports increasingly adopt IoT technologies, they must correspondingly develop cyber resilience strategies to proactively defend against potential cyber risks (Oyewobi et al., 2022). For this, several leading port operators have turned their attention to AI. Indeed, AI algorithms can analyze vast amounts of data generated by the IoT devices onboard ships and throughout the supply chain. By continuously monitoring this data, AI can be expediently applied to quickly detect any anomalies or suspicious activities that may indicate a cyberattack or breach. Utilizing AI as a catalyst for cyber resilience in IoT maritime supply chains is an innovative approach to enhancing security in an increasingly interconnected and digitized industry.

Though cyber resilience ranks among one of the important topics, many ports are however still not sufficiently equipped to effectively mitigate cyber risks (De la Peña Zarzuelo, 2021). To substantitate this assertion, we provide Table 3 which showcases significant recent cyber attacks in the maritime sector, providing insights for future strategies to detect and mitigate cyber risks.

From 2019 to 2024, several studies have been conducted focusing on the identification, mitigation, and enhancement of cyber resilience against IoT vulnerabilities and various cyber risks in the maritime supply chain. Our paper focuses on three concepts that form the cornerstone of our research: Artificial Intelligence (AI), cyber resilience, and IoT. Utilizing AI as a catalyst for cyber resilience in IoT maritime supply chains is an innovative approach to enhancing security in an increasingly interconnected and digitized industry.

Put Table 3: Recent notable maritime cyber attacks here

Thus, the thematic areas explored in the review include cyber resilience in maritime, IoT resilience in maritime, and AI for cyber resilience in maritime. Additionally, our research encompassed studies related to AI for cyber attacks in maritime and cyber risk mitigation in maritime. These themes were investigated using the keywords, which facilitated a focused and comprehensive analysis of the current state of research in this domain. This approach allowed us to not only understand the existing body of knowledge but also to identify the gaps and areas for future research in enhancing cyber resilience within the maritime sector. Table 4 summarizes the extant work exploring the cyber resilience approach in maritime supply chains.

From the survey, it is evident that scholarly efforts are primarily centered at the identification and mitigation of cyber risks within the maritime industry, employing diverse methodologies. The review also reveals a growing recent interest in forecasting cyber-attacks in the maritime sector, with a focus on leveraging AI support. This interest is a response to the growing prominence of cyber attacks. There is a gap in the research, specifically in the realm of using IoT-based vulnerabilities and AI algorithms to address the risks and threats. This gap is particularly pronounced in the context of the ongoing digitalization process, as exemplified by the implementation of smart port applications. This research void has been marginally addressed in the work of Kumar et al. (2023), who explored similar themes.

In response to these findings, our research pivots towards the proactive detection and prevention of potential cyber vulnerabilities, especially within IoT-enhanced prime mover operations at container terminals.

We employ various AI algorithms for this purpose. Our study seeks to assist practitioners in the development of cyber-resilient policies for container terminals. This is achieved by proposing an ad-hoc predicting application, designed for integration with the Terminal Operating System (TOS). Our research contributes to the literature by offering an AI-based strategy for cyber resilience within the maritime IoT supply chain, a subject area that is currently under-studied.

Put Table 4 Cyber resilience in maritime supply chains here

3. Research Method

Our study examines the vulnerabilities in IoT systems introduced by the deployment of wireless communication networks using GPS trackers. These systems are critical for tracking the real-time location and movement of prime movers in container terminals, particularly between the wharf and the yard. Our study seeks to preemptively identify and mitigate IoT security vulnerabilities by recognizing certain anomalies such as frequent unsuccessful login attempts, excessive network traffic, issues in physical devices, unusual location changes, and abnormalities in data transfer packets. These anomalies are indicative of potential IoT vulnerabilities.

To address the cyber risks associated with these vulnerabilities, we employed advanced AI algorithms known for their efficacy in early anomaly detection. These algorithms include Isolation Forest, VAE, and DBSCAN.

- Isolation Forest is particularly effective in high-dimensional scenarios with large datasets, such as prime mover transfer movements tracked by multiple GPS trackers (Villegas-Ch et al., 2023).
- VAE, as a deep learning-based generative model, excel at generating data points akin to training data, aiding in anomaly detection by contrasting the data generated with actual data (Lopez-Martin et al., 2017).
- DBSCAN distinguishes itself by clustering data points based on density and treating non-conforming points as anomalies or outliers. Its capacity to identify outliers in data with varying densities and shapes, without the need to predefine the number of clusters, renders it a potent tool for IoT datasets (Hameed and Idrees, 2021).

To evaluate and compare the performance of these algorithms, we used the usual machine learning metrics such as accuracy, precision, recall, and F1-score (Sajjadi et al., 2018). Specifically, the accuracy metric quantifies the proportion of correct predictions (Makridakis, 1993), precision measures the correctness of positive identifications (Davis and Goadrich, 2006), recall assesses the detection of actual positives (Goutte and Gaussier, 2005), and the F1-score represents the harmonic mean of precision and recall (Chicco and Jurman, 2020). An higher F1-score informs better model performance in prediction.

Our research applied the open-source tool Google Collaboratory for coding and executing these AI algorithms. This platform offers the advantage of leveraging Google's hardware capabilities, independent of personal machine power (Google Colab, 2023).

3.1 Scenario Study

Our work focuses on a scenario study involving container transfer operations at a container terminal, where prime movers play a crucial role in transporting containers between yard and wharf. These operations entail transferring containers discharged from vessels at the wharf in a dual cycle to designated areas, followed by the relocation of containers scheduled for loading onto vessels from their respective areas to the appropriate wharf.

To monitor these operations, GPS trackers were affixed to the prime movers, enabling the real-time tracking of their location and movement. A wireless communication network infrastructure was established, facilitating the transmission of data gathered by IoT devices to a central system. These IoT devices, attached to prime movers and containers, continuously collected data regarding their position and movement.The data, once transmitted through the network, were integrated into TOS. The assimilation of this data into the TOS allowed for the real-time tracking of container movements, enhancing the management of workflows and enabling more informed decision-making with regard to container allocation, yard planning, and berth scheduling.

Figure 2 presents a schematic of the communication network and prime mover operations developed for the IoT infrastructure.

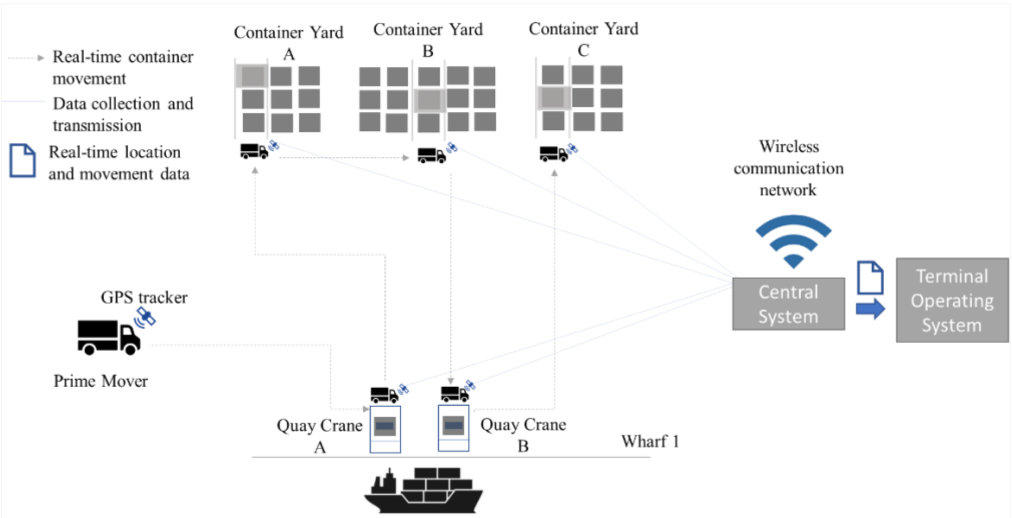

Figure 2: IoT architecture for prime mover real-time operations

The establishment of a wireless communication network, integrated with GPS trackers, introduces potential vulnerabilities inherent to IoT systems, thereby posing a cyber risk. This risk could disrupt container transfer operations performed by the prime movers, and consequently, the overall functionality of the container terminal. The objective of the scenario study is thus to proactively predict these IoT vulnerabilities and implement countermeasures to mitigate the potential cyber risks.

3.2 Data Collection, Preparation, and Training

We employed a synthetic dataset that spans from January to June 2023, comprising data on container transfers from ten prime movers in a local port.The dataset includes:

- Device ID : Identifier for each prime mover's IoT device (PM_1 to PM_{10}).
- Timestamp: The date and time of the record.
- Network activity: Type of network activity (e.g., data sent, data received).
- Data size (KB) The size of the data sent or received during the network activity.
- Login attempt: Indicates whether a login attempt was made (Yes/No).

- Login success: Indicates if the login attempt was successful (Yes/No), applicable only if a login attempt was made.
- Location: Coordinates (longitude and latitude) indicating the geo-location of the prime mover.
- System error code: Error code as E01, E02, and None to denote connectivity issue, hardware malfunction or none,respectively
- Anomaly: Observed anomalies (Yes/No) by standards defined by the container terminal information technology experts

In the training of the models, the dataset was partitioned such that 80% was designated for training purposes, while the remaining 20% was reserved for validation, consistent with current machine learning rules. This division strategy facilitated the model's acquisition of standard behavioral patterns within the training subset and subsequently enabled an evaluation of its proficiency in anomaly detection within the validation subset.The training procedures of the respective algorithms are meticulously designed to accommodate the specificities of each method, namely:

- Isolation Forest: An optimization process is undertaken to ascertain the most suitable threshold for the proportion of outliers within the dataset. A threshold value of 0.34 is deemed to be optimal, indicating that 34% of the data points are classified as anomalies.
- VAE: The architecture utilizes a Mean Squared Error (MSE) threshold of 0.002794 for classification, identified as the optimal demarcation for class differentiation. A fully connected dense layer comprising 128 neurons employs the Rectified Linear Unit (ReLU) activation function. Subsequently, a dense layer with 64 neurons is applied to compute the mean representation in the latent space. The threshold for anomaly detection is established at the 90th percentile.
- DBSCAN: A nearest neighbor model is implemented to ascertain the 20 most proximate data points. The maximum distance between two points for consideration within the same vicinity is set at a value of 2, as inferred from the k-distance graph (see Figure 3), with a minimum cluster formation criterion of 10 points.

- *Put Figure 3: K-distance threshold here*

4. Results and Discussion

4.1 Features Engineering

In our research, we undertake a feature importance analysis to elucidate the significance of individual features in prognosticating the dependent variable. Given the nature of the classification challenge presented by the IoT anomaly data, we employ a Random Forest (RF) classifier, a tool well known for its robust feature importance evaluations (AlSagri and Ykhlef, 2020). The method for the RF classifier incorporates several key procedures:

- Transformation of categorical variables into numerical values.
- Division of the dataset into a training subset, accounting for 80%, and a testing subset, constituting 20%.
- Induction of the RF classifier on the training data.

The findings, as illustrated in Figure 4, underscore the criticality of location of the prime movers and data size attributes in the prediction of anomalies.

Put Figure 4: Feature importance for anomaly detection here

4.2 Model Evaluation

A comparison of the three models reveals divergent performance outcomes. As delineated in Table 5, the empirical evaluation suggests that the DBSCAN anomaly detection model surpasses its counterparts in terms of anomaly detection efficacy within the dataset.

Table 5: Model performance metrics

Model	Accuracy	Precision	Recall	F1-Score
Isolation Forest	0.78	0.62	0.70	0.66
VAE	0.69	0.48	0.16	0.24
DBSCAN	0.83	0.82	0.59	0.68

- Isolation Forest: Exhibited an accuracy of 78%, with a precision rate of 62% for classifying anomalies (class 1). The model successfully identified 70% of authentic anomalies, although the F1-score for class 1 was modestly lower at 0.66, indicating a need for enhanced anomaly classification efficacy.
- VAE: Demonstrated a total prediction accuracy of 69%. Anomaly detection precision was notably low at 48%, with a recall of merely 16%, indicating a substantial number of undetected true anomalies. The F1-score for class 1 was 0.24, signifying suboptimal performance in anomaly detection tasks.
- DBSCAN: Achieved an overall accuracy of 83%, with an 82% precision rate for anomaly (class 1) detection. Nonetheless, the recall for class 1 was 59%, failing to identify approximately 41% of actual anomalies. The moderate F1-score of 0.68 for class 1 suggests that there is scope for refinement on both precision and recall metrics.

The reasons why the models studied in the IoT dataset yielded different performance results can be attributed to several factors as summarized in Table 6.

Put Table 6 here Table 6: Factors affecting model performance

5. Practical Implications

This research holds considerable implications for augmenting cybersecurity measures within IoT-enabled container terminals. The utilization of sophisticated AI algorithms, namely, Isolation Forest, VAE, and DBSCAN, for the preliminary detection of anomalies, exemplifies a forward-thinking strategy for the identification and mitigation of potential vulnerabilities in IoT infrastructure.

The implementation of AI algorithms to identify anomalies in data derived from GPS trackers significantly bolsters the security protocols of IoT frameworks in container terminals. This approach not only aids in the early recognition of cyber threats but also integrates seamlessly into the TOS. Such an integration enhances the efficiency of container movement management, yard planning, and berth scheduling, thereby elevating the overall operational efficiency of these terminals.

A notable aspect of the methodologies employed in this study is the scalability and adaptability of the AI algorithms. They can be effectively transposed to other industry sectors that rely on IoT systems, thereby providing a versatile model for the improvement of cybersecurity across diverse industrial landscapes.

Managers seeking to implement these AI algorithms to detect IoT vulnerabilities based on anomalies in the behavior of activities should consider the specific needs and structure of their dataset and the intended application to ensure optimal performance. A pivotal discovery of this study is the critical role of precise feature identification and prioritization within the dataset. Through meticulous feature engineering, it is feasible to ascertain those features critical to the analysis, consequently improving model predictive accuracy.

Moreover, the study advocates for the continual adaptation and enhancement of these models. By copntinuously refining the algorithms and their features in accordance with specific operational data, container terminals can effectively guard against IoT vulnerabilities, thus advancing their operational efficiency.

6. Conclusion

Employing AI as a catalyst for cyber resilience in IoT maritime supply chains is an innovative approach for enhancing security in an increasingly interconnected and digitized industry. This study contributes to the field of cybersecurity in IoT-enabled container terminals, notable for its novel use of advanced AI algorithms, Isolation Forest, VAE, and DBSCAN, for early anomaly detection. It plugs a gap in the literature by being the first to apply AI-enhanced IoT vulnerability prediction in a container terminal setting. This innovative approach not only bolsters the security framework within such environments but also offers a proactive strategy to identify and mitigate potential IoT vulnerabilities.

The applicaiton of AI algorithms to process GPS tracker data markedly strengthens the security of IoT systems in container terminals, providing a potent method for early detection of cyber threats. AI algorithms can analyze vast amounts of data generated by IoT devices on board ships and throughout the supply chain. By continuously monitoring such data, AI can quickly detect any anomalies or suspicious activities that may signal a cyberattack or breach. Further, integrating anomaly detection into the TOS has yielded substantial improvements in operational efficiency, enhancing container movement management, yard planning, and berth scheduling.

A key recommendation for future studies is the expansion of this research by incorporating additional features into the IoT vulnerability prediction model. This expansion could provide a richer understanding of the vulnerabilities and enhance the predictive accuracy of the system. Also, this study lays the groundwork for ad-hoc applications within the TOS, serving as a foundational piece for cybersecurity risk mitigation strategies in container terminal operations.

This study's emphasis on tailored AI model selection based on dataset specifics and application goals underscores the value of precision in achieving optimal performance. The critical role of feature engineering in refining the models' predictive capabilities is also highlighted. Our work advocates for a dynamic, evolving approach to model application, urging continuous refinement based on specific operational data to effectively tackle the evolving nature of cybersecurity threats in IoT infrastructure. As we progress in an increasingly connected world, the methods and insights from this research can serve to shape the future of cybersecurity in IoT systems in other industries or supply chains.

Sustainability in Logistics and Supply Chains

Efficiency comparison to improve sustainability of Australian banana farms

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INTRODUCTION

Australia produced 374,033 tonnes of banana in 2022 valued at $501.6 million (Hort Innovation, 2022). The 2021-22 ABARES Horticulture Survey reported banana crop loss/waste as an average of 29% per farm (Downham, 2022). If one third of this crop loss/waste could be salvaged and became crop sale, another 50,925 tonnes of banana valued at $68.3 million would be available to the market. From another perspective, if one third of the crop loss/waste could be avoided through better utilisation of resources and more efficient farm management, a significant amount of production cost could be reduced, thereby improving the profit margin of the banana growers and sustainability of the banana growing industry.

Crop loss/waste at banana farms during the production stage refers to many things including overproduction, plant residues, rejected or damaged bananas, surplus packaging materials, unused or expired input such as fertilisers, pesticides, or herbicides, poor water and soil management, as well as loss during post-harvest processing. Various factors can lead to crop loss/waste which include climate, farming, harvesting, and processing technology, farm management, customer demand, and cosmetic standards of retailer, among others. As such, it is difficult for banana growers to control the output apart from setting a production target at the beginning of the growing season. In contrast, it is easier for the growers to control the output in terms of fertiliser and chemical usage, water management, packaging, and post-harvest processing procedures. Top performing banana growers are generally more efficient in utilising the various resource as well as adopting superior farm management practices to reduce waste. As a result, they can produce more output per hectare or use less water and fertiliser to produce the same output. This can result in higher net return per carton of banana produced.

To help reduce waste and achieve sustainability in the horticulture industry including banana growing, it is crucial to improve farming practice and farm management technique to improve efficiency. While government, NGO, and academia can provide support to growers through extension services, workshops and training programs, demonstration farm, expert advice, field trials and research, etc., growers themselves can also learn from their more efficient peers by joining farmers' cooperatives and groups to benefit from group training sessions, knowledge exchange, and joint efforts to improve farming practices. They can also network with successful farmers to benefit from their experiences, practical tips, and valuable insights. In this regard, it would be critical to analyse the current levels of efficiency of the individual growers and identify the more efficient ones as peers or benchmarks for others to learn from.

This research aims to apply the data envelopment analysis (DEA) technique to achieve the above-mentioned purpose. Developed by Charnes et al. (1978, 1981), DEA measures the performance of firms (or decision-making units DMUs) based on multiple inputs and outputs. In DEA, firm efficiency is defined as the ratio of the sum of its weighted outputs to the sum of its weighted inputs (Thanassoulis et al., 2008, p. 264). Each firm's efficiency score is calculated relative to an efficiency frontier. Firms located on the efficiency frontier have an efficiency score of 1 (i.e., 100%). Firms operating beneath the frontier have an efficiency score inferior to 1 (i.e., less than 100%) and hence have the capacity to improve future performance. Firms located on the frontier serve as benchmarks – or peers – to inefficient firms. These benchmarks are associated with best practices. As such, DEA is widely considered as a powerful benchmarking tool from an efficiency perspective (Huguenin, 2012; Wojcik et al., 2019).

LITERATURE REVIEW

The Australian banana supply chain is largely contained within Australia with no fresh bananas imported and only a few growers representing less than 1% of production exploring the export market (Australian Banana Growers Council, 2024). Coupled with the characteristics of banana supply chain such as farm location and distance from markets, production scale, agronomic practices, enterprise sophistication and available resources, management preferences, contractual arrangements with big buyers, and stringent cosmetic standard of retailers, overproduction and hence crop loss/waste is a major challenge for the sector (Messner et al., 2021). The 2021-22 ABARES Horticulture Survey reported that the average percentage of crop waste for bananas in Australia was 29% per farm (Downham, 2022).

While the issue of overproduction hence resulting in waste due to contractual arrangement and cosmetic standards of retailers arising from power imbalance in the banana supply chain is not easy to address in the short run, crop loss/waste arising from inefficient use of labour, water, energy, fertiliser, and packaging method can be improved relatively quickly through changes in farming practices and farm management skills (Goodwin, 2023). Less efficient farms can learn from more efficient farms through the support of trade association or government. Smaller farms can also collaborate to maximise usage of resources or merge to form larger farms to improve efficiency. Prior to that, it is necessary to find an easy and less data hungry way to benchmark the efficiency of farms. Data envelopment analysis (DEA) based on certain outputs and inputs has been widely used in agricultural research for benchmarking (see for example Atici & Podinovski, 2015; Picazo-Tadeo et al., 2011; Wagan et al., 2018).

The use of DEA for efficiency analysis of banana farming is relatively scarce, probably due to difficulties in primary data collection. Therefore, many of these limited studies used secondary data published in yearbooks or industry survey reports for analysis (see for example Lin et al., 2019; Morales Molina et al., 2023). As such, the use of output and input variables in their DEA models were confined by the data published in the yearbooks and the reports. In general, production quantity or value per hectare is used as output variable whereas quantity or cost of labour, irrigation, fertiliser, chemical and herbicide usage, packaging, machine maintenance, etc. are used as input variables (see for example, Lin et al., 2019; Kumar & Kumar, 2016). In many of these studies, the focus is on performance or production efficiency comparison (Indana et al., 2018; Wagan et al., 2018), few have applied DEA to identify areas of improvements in farming practice, farm management, or sustainability development. An exception is Picazo-Tadeo et al. (2011) who used DEA to assess agricultural sustainability or farming eco-efficiency at farm level of Spanish farmers operating in the rain-fed agricultural system of Campos County. The results revealed that farmers were quite eco-inefficient, due to technical inefficiencies in the management of inputs and lack of eco-efficiency training. Similarly, Ait Sidhoum et al. (2020) measured sustainability efficiency, or success in achieving sustainability policy goals, of Catalan arable crop farms using DEA. The findings showed that, on average, farms displayed high technical and social performance and relatively poor environmental performance.

METHODOLOGY

There are two models in DEA: CRS and VRS, each has its own efficiency frontier. Firms (or DMUs) located on the frontier is 100% efficient while those located beneath it are less efficient. The gap observed between the CRS and the VRS frontiers is due to a problem of scale. The CRS model assumes constant returns to scale technology. To operate at optimal scale, firms should evolve in a perfectly competitive environment which is practically rare. The VRS model assumes variable returns to scale technology. It acknowledges that firms are not all operating at optimal scale due to various constraints. As the VRS model takes into account the actual scale at which each firm operates, recognises that a firm may experience economies of scale (efficiency improvements with scale) or diseconomies of scale (efficiency deterioration with scale), and allows for a more flexible representation of the production technology, accommodating different scale efficiencies, such flexibility can lead to the identification of more efficient firms, especially when operating conditions deviate from the assumptions of constant returns to scale. If a firm is technically efficient (i.e., sitting on the efficiency frontier with VRSTE=1) but not totally efficient (i.e., sitting on the efficiency frontier with CRSTE=1), it means the firm can change its scale by either increasing or decreasing its size through splitting into smaller firms or merging with another firm to form a bigger one to become totally efficient.

If a firm is located under the efficiency frontier in a VRS model, it means that the firm not only has a scale problem but is also poorly managed. It should eliminate the inefficiency attributable to poor management first to become VRS efficient. Then, it should eliminate the inefficiency attributable to a problem of scale to become CRS efficient.

A DEA model can be input or output oriented. In an input orientation, DEA minimises input for a given level of output. It indicates how much a firm can decrease its input for a given level of output. In an output orientation, DEA maximises output for a given level of input. It shows how much a firm can increase its output for a given level of input. The model's orientation should be selected according to which variables (inputs or outputs) the decision maker has most control over. It should be noted that while the efficiency scores in a CRS model are the same for an input or an output orientation, they are different in a VRS model due to the problem of scale.

If a firm is facing increasing returns to scale, it means a variation in output of 1 percent would result in a variation in input of less than 1 percent. As such, increasing the size of operation or merging with another firm to fully utilise the input resources would help the firm reach optimal scale. Conversely, if a firm is facing decreasing returns to scale, it means a variation in output of 1 percent would result in a variation in input of more than 1 percent. Therefore, downsizing or splitting the firm into two to rationalise the use of input resources would assist in scale optimisation. For a totally efficient firm, it is facing constant returns to scale. Such a firm has reached its optimal size (or efficient scale). It is operating at a point where the scale (or size) has no impact on productivity. This situation occurs when the average inputs consumption is minimised and does not vary with output. In a situation of constant returns to scale, an increase in output of 1 percent requires a proportionate increase in input (i.e., 1 percent).

In DEA, the closest efficient firms located on the frontier for each inefficient firm are identified as peers or benchmarks. If inefficient firms want to improve their performance, they can learn from the best practices developed by their respective peers.

This study uses a VRS model with input orientation to analyse the efficiencies of 27 Australian banana farms located in the states of Queensland, New South Wales, and Western Australia. Owing to keen competition, banana growers in Australia are generally reluctant to share sensitive data about their production. Secondary data are therefore used in this research. The data are extracted from the report on Banana Enterprise Performance Comparison published by Horticulture Australia Limited (HAL) in 2011 (Comiskey, 2011). HAL was a not-for-profit company that worked in partnership with the Australian government and horticulture industries. Its primary focus was on research and development, marketing, and the coordination of industry initiatives to enhance the competitiveness and sustainability of the horticulture sector. In 2014, it transitioned and was renamed as Horticulture Innovation Australia Limited (or Hort Innovation in short) to become a grower-owned, not-for-profit, unlisted public company limited by guarantee and the declared industry services body for horticulture under the Horticulture Marketing and Research and Development Services Act 2000.

Confined by the availability of data, the model of this research comprises one output and four inputs (see Table 1). In the 2011 research conducted by HAL, 46 banana growers, who represented 22% of the total area of banana production in Australia at that time, participated in the survey. Their business scale ranged from less than $250,000 to greater than $10 million in annual turnover. The data compiled relate to a single year, 2008/09, and are not necessarily indicative of industry performance across multiple years. Upon removing the cases with missing values and outliers, data from 27 growers were used in the analysis. As a proof-of-concept study, the available sample is considered sufficient as the number of DMUs exceeds three times the combined number of inputs and outputs to provide an adequate number of degrees of freedom for optimisation (Cooper et al., 2006).

Table 1 Variables and average values of the sample data

Variable	**Type**	**Unit**		**2008/2009**
Cartons packed per farmed hectare	Output	carton	Mean	2247
			S.D.	716.6
			Min.	1115
			Max.	3575
Wages and contract labour services	Input 1	$/carton	Mean	4.1
			S.D.	1.3
			Min.	2.1
			Max.	7.2
Fertiliser and chemical cost	Input 2	$/carton	Mean	2.4
			S.D.	1.1
			Min.	0.9
			Max.	4.9
Packaging cost	Input 3	$/carton	Mean	2.5
			S.D.	0.4
			Min.	1.6
			Max.	3.6
On-costs and owner salary	Input 4	% of total on-farm costs	Mean	2.7
			S.D.	1.7
			Min.	0.6
			Max.	7.4

Source: Comiskey, S. (2011) Banana Enterprise Performance Comparison. Horticulture Australia Ltd., Project No. BA09039 (May 2011)

To determine if the output and the inputs are appropriate for use in the model, correlation between the partial indicators of efficiency were examined to see if they yielded meaningful information. An output to input ratio was calculated for each of the inputs and correlation coefficients between the partial indicators for all farms were then computed (see Table 2). The results show that the different partial indicators can yield consistent yet diverse outcome regarding farm level performance. They are deemed useful in measuring the performance of a farm from various perspectives to derive an overall efficiency score.

Table 2 Correlation coefficients of output/input ratios

	Output/Input 1	**Output/Input 2**	**Output/Input 3**	**Output/Input 4**
Output/Input 1	1			
Output/Input 2	0.6040*	1		
Output/Input 3	0.7799*	0.7569*	1	

Output/Input 4	0.2664	0.5532*	0.5796*	1

* significant at .01 level

FINDINGS

Using a VRS input oriented model to analyse the data, the efficiency scores of the 27 farms are shown in Table 3. The distribution of the efficiency scores is shown in Table 4.

Table 3 Farm efficiency scores

Farm	CRS input oriented (CRSTE)	VRS input oriented (VRSTE)	Scale Efficiency (SE)	Returns to Scale	Peers (in order of lambda weights)
1	0.452	0.696	0.650	Increasing	20, 27, 2
2	0.822	1.000	0.822	Increasing	-
3	0.297	0.596	0.498	Increasing	13, 20, 15
4	0.661	0.721	0.917	Increasing	20, 17
5	0.275	0.725	0.380	Increasing	20, 12
6	0.439	0.674	0.651	Increasing	20, 13
7	0.575	0.764	0.753	Increasing	20, 2
8	0.446	0.724	0.616	Increasing	20, 2, 15
9	0.920	1.000	0.920	Increasing	-
10	0.454	0.710	0.640	Increasing	15, 20, 2
11	0.363	0.852	0.426	Increasing	27, 20, 2
12	0.640	1.000	0.640	Increasing	-
13	0.745	1.000	0.745	Increasing	-
14	0.814	0.925	0.880	Increasing	27, 20, 2, 15
15	0.964	1.000	0.964	Increasing	-
16	0.249	0.759	0.328	Increasing	20, 9
17	0.895	1.000	0.895	Increasing	-
18	0.265	0.615	0.431	Increasing	20
19	0.207	0.618	0.335	Increasing	20, 2
20	1.000	1.000	1.000	Constant	-
21	0.317	0.744	0.426	Increasing	20, 2, 15
22	0.380	0.694	0.547	Increasing	20, 12
23	0.525	0.954	0.550	Increasing	13, 12, 20
24	0.407	0.682	0.596	Increasing	20, 2
25	0.457	0.705	0.648	Increasing	20, 2
26	0.906	0.947	0.957	Increasing	20, 12
27	1.000	1.000	1.000	Constant	-
Mean	0.573	0.819	0.675		
S.D.	0.261	0.149	0.215		
Min	0.207	0.596	0.328		
Max	1.000	1.000	1.000		

Table 4 Distribution of efficiency scores (input oriented)

Efficiency Scores	CRS Technical Efficiency	VRS Technical Efficiency	Scale Efficiency
> 0.0 and ≤ 0.1	0	0	0
> 0.1 and ≤ 0.2	0	0	0
> 0.2 and ≤ 0.3	5	0	0
> 0.3 and ≤ 0.4	3	0	3
> 0.4 and ≤ 0.5	6	0	4
> 0.5 and ≤ 0.6	2	1	3
> 0.6 and ≤ 0.7	2	6	6
> 0.7 and ≤ 0.8	1	8	2
> 0.8 and ≤ 0.9	3	1	3
> 0.9 and ≤ 1.0	5	11	6

Taking Farm 1 in Table 3 as an example, the CRSTE of 0.452 suggests that assuming CRS the farm could reduce its inputs by 54.8% (i.e., 1 – 0.452) and still be able to produce the same output. In a CRS model, technical efficiency scores have the same values in an input or an output orientation. It means that Farm 1 can increase its output by 54.8% using the current inputs. In other words, if CRS is assumed, Farm 1 can either reduce its inputs by 54.8% or increase its output by 54.8% to become efficient (i.e., 100%).

As an input oriented VRS model is selected, the focus is on input reduction. The VRSTE of 0.696 implies that Farm 1 has a 'pure' efficiency score pf 69.6%. The inefficiency is due to poor management. By improving the operation of the farm alone, 30.4% (i.e., 1 – 0.696) of inputs could be saved. The SE of 0.650 implies a scale efficiency of 65%. The farm is facing increasing returns to scale suggesting that to reach optimal scale the farm could increase its size of operation through internal growth or by merging or collaborating with another farm which is also facing increasing returns to scale. By adjusting the farm to its optimal size alone, 35% (i.e., 1 – 0.65) of inputs could be saved.

To improve its efficiency, Farm 1 can analyse the practices of Farms 20, 27, and 2, which are identified as its peers or benchmarks. The lambda weight associated with each peer corresponds to its relative importance among the peer group. Ideally, Farm 1 should analyse the best practices from all the three farms. In reality, it could concentrate its best practice analysis on the peer associated with the highest lambda value (i.e., Farm 20).

It should be noted that DEA calculates relative and not absolute efficiency scores. Although firms on the efficient frontier are given a 100% efficiency score, it is likely that they could further improve their productivity through various improvements such as technological upgrades.

Table 4 shows that 11 (41%) out of 27 farms were more than 90% technically efficient. 8 (or 30%) are found to be 100% efficient relative to the others. In terms of scale efficiency, they are not doing too well as only 6 (or 22%) were efficient at 90% or higher. All, except two with 100% efficiency, are facing increasing returns to scale implying that there is room for increasing the farm size to improve efficiency. In other words, while there is scope for many farms to improve their farming practices and farm management to become more technically efficient, there is a much bigger room for increasing their scale of operation by expanding the farm size or collaborating with other farms to achieve economies of scale.
Table 5 shows the average savings in input use across all the 29 farms. The average savings upon improvement in farm management (i.e., to become 100% technically efficient) in the four inputs are found to be 25.3% in employee wages, 34.7% in fertiliser usage, 20.6% in packaging cost, and 30.0% in on-costs respectively. It should be noted that In a VRS model, the improvement in variables (decrease in inputs or increase in outputs) is calculated according to the VRS technical efficiency score only. Scale efficiency

is not considered. It implies that further savings can be achieved through scale improvement in addition to farm management improvement.

Table 5 Average saving in input use across all 29 farms

Input	Unit	Average Original Value	Average Projected Value	Average Saving (% of Original)
Wages and contract labour services	$/carton	4.078	3.048	1.030 (25.3)
Fertiliser and chemical cost	$/carton	2.389	1.559	0.830 (34.7)
Packaging cost	$/carton	2.548	2.023	0.525 (20.6)
On-costs and owner salary	% of total on-farm costs	2.711	1.897	0.814 (30.0)

DISCUSSION

The above findings reveal that most of the farms in the sample were not operating at top efficiency due to deficient farming practices, defective farm management, or suboptimal scale. There is a clear and significant difference in performance between the most efficient farms (8 with VRSTE=1) and those which are less efficient (19 with VRSTE<1). Table 6 shows that on average the most efficient farms produced almost 38% more than their less efficient counterparts and used 20% and 24% less labour and fertiliser during production. They were also more cost-effective in packaging and farm management with cost reduction of 7% and 11% respectively.

Table 6 Comparison of performance between the 100% efficient farms with the others

Input	Unit	Average Value of 8 Farms with VSRTE=1	Average Value of 19 Farms with VRSTE<1	Difference (% of Average Value of 19 Farms with VRSTE<1)
Cartons packed per farmed hectare	cartons	2783	2021	+762 (+37.7)
Wages and contract labour services	$/carton	3.475	4.322	-0.847 (-19.6)
Fertiliser and chemical cost	$/carton	1.950	2.574	-0.624 (-24.2)
Packaging cost	$/carton	2.413	2.605	-0.192 (-7.4)
On-costs and owner salary	% of total on-farm costs	2.476	2.810	-0.338 (-12.0)

The findings align with those reported in HAL's (2011) Banana Enterprise Performance Comparison study. In that project, average inputs and outputs of the top 10 farms were compared with the rest to identify the performance gaps. As the comparison was based on one variable at a time and the top 10 farms (out of 46 growers) differed in each comparison, the outcome was not as consistent as that of the current study using DEA. Nevertheless, it still provided a general picture which could be used as a cross validation of the current DEA approach. The HAL's study findings showed that the top 10 farms were 39.6% more productive (in terms of cartons per hectare) than the remainder. It was reported that a primary reason for this could be the strong crop management skills of these growers as they had the ability to produce significantly larger percentages of extra-large bananas compared with other growers. The top 10 farms also had labour costs (owners, employees, and contractors) 25.5% lower per carton. This could be indicative of these growers having more developed human resources management skills and more efficient farming and packing systems. Fertiliser and chemical usage costs were 9.8%

lower than for the remaining growers. The lower costs per carton were believed to be largely due to the higher yield per hectare. The on-farm costs per carton was 25.9% lower suggesting that farm management practices of the top 10 farms could be more cost-effective.

The HAL's (2011) Banana Enterprise Performance Comparison project highlighted significant differences in the farm management activities of individual growers which in turn could lead to a wide variation in business profitability. The DEA approach adopted in this study provided a more comprehensive and consistent analysis of the efficiencies of the farm to reach the same conclusion. Not only it highlighted for each farm the areas for improvement in terms of input utilisation but also identified the more efficient peers to learn from in terms of farm management practices. As such, the strong capability of DEA as a benchmarking tool was clearly demonstrated.

CONCLUSION

This study shows that sustainability of banana farms can be improved by comparing their operating efficiencies and identifying areas for improvement using the DEA technique. The findings can help reduce wastage at growing stage which is one of the major issues in the horticulture industry. Data from 27 Australian banana farms in the states of Queensland, New South Wales, and South Australia were analysed using DEA. A VRS model with input orientation was employed comprising one output (cartons packed) and four inputs (employee wages, fertiliser usage, packaging cost, and on-costs). Among the 27 farms, 11 (or 41%) are found to have technical efficiency score over 90%. 8 (or 30%) are found to be 100% efficient relative to the others. Two farms are found be to be major peers or benchmarks for others to learn from. Only 6 out of 27 (or 22%) farms are found to have scale efficiency scores over 90%. All, except two with 100% efficiency, are facing increasing returns to scale implying that there is room for increasing the farm size to improve efficiency. The average savings upon improvement in farm management (i.e., to become 100% technically efficient) in the four inputs are found to be 25.3% in employee wages, 34.7% in fertiliser usage, 20.6% in packaging cost, and 30.0% in on-costs respectively. As a proof-of-concept study, this research contributes to knowledge of horticulture waste reduction through farming improvement in terms of better utilisation of labour, fertiliser, packaging, and other resources. It shows that through improved farm management resulting in more efficient usage of inputs, the cost of production can be minimised to obtain a target output which helps achieve sustainability in the long run. Nevertheless, firm practices and technologies may have evolved over the past decade, highlighting the need to identify additional variables—both input and output—that best represent firm efficiency. For instance, the efficient use of water and electricity in line with green agricultural practices, geographical dimension (longitude and latitude of farm), and temporal variations (time series of costs and climate conditions) that might impact farm efficiency, should be considered. Future studies should take these factors into account.

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Evaluating the impact of logistics service quality on Gen-Z's customer satisfaction: A Case Study on E-Commerce in the Northern Region of Vietnam

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Abstract

In the booming era of e-commerce, logistics plays an essential role in the growth of profits and competitiveness of logistics providers. Based on the concept of LSQ of MENTZER et al. 1999, logistics service quality can be considered as a set of dimensions, including staff service quality, communication service quality, after-sale service quality, and delivery service quality, which results in the level of customer satisfaction. Regarding geographical positioning, the Northern area of Vietnam has considerable potential for E-commerce development. This research uses descriptive research to empirically analyze logistics service quality's influences on customer satisfaction to clarify the critical logistical factors affecting consumer satisfaction based on the Vietnamese Generation Z consumer's perspective. To identify the relationships between E-commerce logistics service quality and Gen Z's customer satisfaction, the study conducted descriptive statistics, factor analysis, reliability tests, and multi-linear regression with SPSS 25 based on the data collected through online questionnaires with total respondents of 220 Gen-Z online shopping users in Northern region of Viet Nam. The results conclude that the quality of logistics services directly and positively impacts Generation Z customer satisfaction. This study helps e-commerce logistics service providers understand their younger customers and improve service quality to keep existing customers and attract new ones. However, the study still has some limitations; the research only focuses on the point of view of young Vietnamese online shopping customers from the Northern region. For better evaluation, the perspective of logistics providers is also essential for future studies to compare with another generation of customers and those living in other areas of Vietnam.

Keyword: Northern region of Vietnam, Gen-Z Customer Satisfaction, E-commerce Logistics service quality, Factor analysis, Multi Linear Regression.

1. Introduction

The advent of the Industrial Revolution 4.0 has prompted widespread recognition and ongoing interest in e-commerce by several nations, owing to its substantial impact on fostering economic expansion. Vietnam has emerged as one of Southeast Asia's rapidly expanding e-commerce marketplaces. (World Bank, 2022). The Vietnam E-commerce Association's (2022) report on the Vietnam e-business index for 2022 reveals that approximately 53% of the population engaged in online shopping activities. This resulted in a 20% growth in the e-commerce market in Vietnam during 2021, reaching a total value of 16 billion USD. This figure is estimated to represent estimated that this figure represents approximately 5.5% of the overall retail sales of consumer goods and services across the country. Vietnamese consumers now have more and more opportunities to choose the company with the best service to meet their demand. Enterprises that want to survive and develop must find ways to improve their competitiveness, along with improving customer satisfaction. Especially for e-commerce logistics companies, it must be a mandatory priority, while the e-commerce industry is significantly growing in Vietnam. Therefore, Vietnamese consumers are becoming more and more demanding through the higher demands on E-commerce logistics services quality day by day.

Generation Z, often known as Gen Z, comprises a cohort of youthful individuals living in a technologically advanced society with considerable potential as consumers. The Generation Z cohort has been introduced to technology from a young age. This factor significantly impacts their purchasing patterns and conduct. Customers spend significant time engaging in web browsing and online purchasing activities, particularly during monthly advertising campaigns or flash sales events. Therefore, if generation Z expresses contentment with a particular brand or promotional initiative, it is probable that they will exhibit enduring loyalty towards it, even without promotions. The generation Z consumer segment is recognized for having significant online buying influence. This is primarily due to the projected increase in generation Z's representation within the national workforce, estimated to reach around 25% by 2025. Consequently, this demographic is expected to include a considerable consumer base, equal to approximately 15 million VND prospective customers. In the northern region of Vietnam, it has been observed that around 88% of individuals belonging to Generation Z engage in online buying activities. (Ha, N., & Nguyen, T., 2016).

Numerous scholarly investigations have examined the beneficial impact of electronic logistics service quality (e-LSQ) on client satisfaction throughout the purchasing product and subsequent customer loyalty in the purchase process (Griffis et al. 2012). Research from Wicks and Roethlein (2009) has shown that a business that regularly meets the needs and expectations of its consumers is more likely to have enhanced financial advantages and better profitability due to the establishment of stronger customer loyalty. Accordingly, most firms have consistently endeavored to cultivate client loyalty by offering consumers optimal advantages, fostering a strong affinity for the brand. Customers develop their preferences based on their perceptions and attitudes towards different brands.

So far, there have been many studies on logistics service quality and customer satisfaction. However, very few studies have studied the relationship between different aspects of logistics services quality and customer satisfaction from the customer's point of view. This study aims to fill this void and explore customer's perspective in Viet Nam. Thus, the primary aim of this research is to examine the reciprocal relationship between the factors of e-commerce logistics service quality and the satisfaction levels of generation Z customers in Northern region of Vietnam. Additionally, this study endeavors to construct a comprehensive measurement scale for evaluating the impact of e-commerce logistics service quality on the satisfaction of generation Z customers. The results of this study provide valuable insights for E-commerce logistics providers seeking to enhance their logistical services.

2. Literature Review

2.1. E-commerce logistics service quality

In Vietnam, the official concept of logistics services was introduced for the first time in the 2005 Commercial Law of Vietnam (Article 233). "Logistic services are commercial activities whereby traders organize the performance of one or many jobs including reception, transportation, warehousing, yard storage of cargoes, completion of customs procedures and other formalities and paperwork, provision of consultancy to customers, services of packaging, marking, delivery of goods, or other services related to goods according to agreements with customers in order to enjoy service charges". According to ESCAP, logistics is a scientific field that encompasses the systematic organization and efficient management of the flow of products and services, starting from the preproduction phase and concluding with the delivery of these items to the end customer. Also, logistics is examined as a service linked to the distribution and circulation. In the online shopping environment, logistics services are closely linked with customers. From customer point of view, valuation after purchase shows how many customers value the quality of logistics. Service quality is an important factor affecting customer satisfaction, also one of the important things for their online shopping experience, logistics and quality linkages have a positive impact on customer satisfaction. Thorough, timely and reliable logistics can effectively improve customer satisfaction. Franceschini and Rafele (2000) implemented six components to measure logistics service quality including reliability, productivity, lead time, harmfulness, productivity, and regularity. Collona (1997) promoted the customer satisfaction theory of Parasurman et al (1985) to appraise the quality of services in logistics field. In his research, he suggested four components as: reliability, empathy, responsiveness, and assurance of logistics services. Huang et al (2009) used 5 factors are: the quality of information, timeline, loyalty, purchase conditions and order discrepancy handling to investigate different model to classify the logistics service quality. According to Mentzer et al. (2001), proposed a customer based LSQ model in a 1999, time-based and logistics service process. The model is used to study the correlation between different dimensions, comparison of how the different aspects of logistics service quality affect customer satisfaction in different markets segmentation. From the customer's perspective, the quality of logistics services in this study covering the general process from point of order to delivery finished. Customer satisfaction related to E-commerce logistics service quality to minimize the provider damage while maximize their profits and gain more and more customer loyalty.

E-logistics refers to the use of Internet-based technology to facilitate many aspects of the supply chain, including procurement, warehousing, transportation, and distribution. This is achieved via the implementation of route optimization techniques and the monitoring of inventories. (Bayles, 2002). E-logistics may be defined as the outcome of integrating e-commerce with logistics. According to the research conducted on the LSQ model, e-LSQs refer to the components of the LSQ model that function inside the online setting (Mentzer et al. 2001). From the logistics provider's point of view, the measurement of e-LSQ refers to the capacity to effectively meet customer orders, explicitly referring to the ability to fulfill orders and complete customer satisfaction inside electronic markets (Sorkun et al. 2020). Thus, the quality of logistics services in e-commerce refers to fulfilling client requirements throughout the purchasing experience inside the e-commerce environment.

2.2. Customer Satisfaction

Oliver (1980) introduced the theory of satisfaction of customers for the quality of good service an organization's product with two influencing factors that independence is the customer's expectation of the service before you buy and get a feel for that service experience. Satisfaction is the person's satisfying response consumption and definition is the psychological state of cold contact around the expectations associated with consumers' previous feelings of adoption customer experience (Oliver, 1997, 13). Yang & Peterson (2004) and Chen & Tsai (2008) said that a customer satisfaction is a concept that measures all levels of satisfaction of that customer with the service provider after all interactions and interactions with customer.

Customer satisfaction has been defined as an overall evaluation of a firm's post-purchase performance or utilization of a service (Fornell, 1992). Parasuraman et al. (1988) state that satisfaction research is mainly aroused from a cognitive process in which the customer’s feeling of satisfaction is a result of a comparison process between perceived performance and one or more comparison standards, such as expectations. Satisfaction can also be defined in transaction-specific and cumulative aspects. Because of some advantages of cumulative satisfaction, including, more thorough measurement of the customer’s consumption utility, subsequent behaviors, and economic performance, it has been usually viewed in this manner by many researchers (Johnson et al., 2001). This approach defines satisfaction as a customer’s overall experience, to date, with a product or service provider (Johnson and Fornell, 1991). In addition, Andreassen and Lindestad (1998) suggest that the customer satisfaction indicators should address overall satisfaction and congruence with expectations. Thus, the authors measure this construct with overall satisfaction level of customers, fulfilment of their expectations and company’s performance versus that of the ideal provider.

3. Research Hypotheses and research model

3.1. Logistics service quality

Collona (1997) promoted the customer satisfaction theory of Parasurman et al (1985) to appraise the quality of services in logistics field. In his research, he suggested four components as: reliability, empathy, responsiveness, and assurance of logistics services. Huang et al (2009) used 5 factors are: the quality of information, timeline, loyalty, purchase conditions and order discrepancy handling to investigate different model to classify the logistics service quality. Additionally, MENTZER et al (2001) has pointed out that the goal of logistics is the customer, so it's more reasonable and gives decision-makers a more practical meaning to define and evaluate the quality of logistics services. From the customer's perspective, the quality of logistics services in this study covering the general process from point of order to delivery finished. Customer satisfaction related to E-commerce logistics service quality to minimize the provider damage while maximize their profits and gain more and more customer loyalty. Research result of many authors have shown that the most criteria for E-commerce logistics service quality effect on customer satisfaction are directly and indirectly the profits of the firms. The model contain order deliver quantity, ordering procedures, cadre contact quality, order divergence and order truthfulness.

3.2. Communication service quality criteria

According to Parasuraman et al. 1985, the level of customer’s expectations might be increase through the communication between the contact person and the consumer during the order and delivery process. Bitner et al. (1994) stated the correct understanding of customers by the front-line employee as part of the contact staff, facilitate approval expectations and needs of customers. Essential characteristics of service personnel, such as experience, empathy with the customer's situation, their desire to solve problems in the delivery process and its approach to interaction between customer affects it customer perceptions of the quality of the services they have used (Bitner et al., 1994; Mentzer et al., 2001). There are 3 elements of service quality was classified by consumer are cooperate quality, interactive quality, and physical quality. It is considered interactive feature interaction between clients and contact personnel and another customer is the essential aspect of the quality of service. Recently, logistics information systems are used to enable logistics services also increase the perception of service quality. The information system in logistics includes the interior and the exterior to share the information. While trading internally for information in logistics allows to increase quality of service increasing its punctuality and precision orders in service, exchange of external information, including the exchange of information in real time with customers, help close the gap in the quality of service that customers expect. (Parasuraman et al.,1985).

Therefore, the first hypothesis is given as follows:

H1: Communication service quality criteria positive impact on the level of customer satisfaction on E-commerce logistics service quality in Viet Nam.

3.3. Delivery service quality criteria

According to Parasuraman et al., 1985: "The process of service delivery has great importance in expectations as much as the outcome of a service". One the most important of service quality is delivery on time. It refers to whether the goods arrive at the right place or not right time. It can measure the delivery time on time. This is an important factor to consider, because under the current high level of competition, non-compliance with delivery schedules is unacceptable. This affects the need for increasingly complex computer processes. Hummels and Schaur (2013) conclude that a 1% reduction in exporters' container handling time could increase bilateral trade by 0.4%, while a 1% reduction in variable transit time could increases bilateral trade by up to 0.2%, meaning better timeliness and predictability of goods arrival can increase trade. In terms of value, the cost of the same day transport is equivalent to 0.6-2.1% of the value of the cargo (Hummels and Schaur, 2013). Reducing transit times is one of the key goals of the transport policy; often influences performance indicators used for policy evaluation in cost-benefit analysis. Hult et al. (2000) defining cycle time include shipping time and reorder time when the product is inconvenient it is the most important thing. Factors that show the performance of the distribution system (Hult et al, 2000; Mentzer et al., 2001; Mentzer et al.,1999). Transit time is the key element of the logistics process as well as to influence the customer which include time for responding order, time for handling order by e-merchant, time for delivering product and time to reverse the logistic (Lina et al., 2014). It is ranked as the second important element for firms with an attribute of transit time speed (Pearson & Semeijn, 1999). Thus, this factor cannot be neglected in case of customer satisfaction. There is always a high importance given by companies, especially shippers to transit time (Collison, 1984; McGinnis, 1990) because it is one of the most important aspects of e-logistic services. Low transit time creates a positive image of e-logistic companies which encourage customers to purchase through e-logistic. Thus, low transit time has a positive influence on e-logistic customer satisfaction. When an order purchase online, the customer can't receive their goods immediately, they need to wait a period of time to receive it so their expectation is they want the right thing, right time and best quality.

Therefore, the second hypothesis is given as follows:

H2: Delivery service quality criteria positive impact on the level of customer satisfaction on E-commerce logistics service quality in Viet Nam.

3.4. After-sale service quality criteria

The customer can only have an idea of the information of the merchandise through the image and description of the merchandise when buying online. This makes it sometimes unavoidable for customers to accept damaged goods or merchandise. That did not match their expectations. If the seller can propose measures ahead of time for the transaction to those problems and take relevant measures in time to solve the emerging problems, can show accountable to customers and help customers shop more safely. Parasuraman et al.,1985 claimed that in the traditional purchasing environment, the recovery behavior of the company's service will affect satisfaction and loyalty. To put it plainly, the timeliness and integrity of after-sales measures could be better customer shopping experience and increase their satisfaction. After-sales service is the service provided for customer after product delivery (Rigopoulou et al., 2008). After-sales service is often used in a manufacturing. Production companies strive to meet customer needs with product design, comprehensive product supply, and consumer support after-sales service. Also, the expectation and satisfaction of the customer with the provider is when their order products have damaged, the providers always have a good return and refund policy for them.

Therefore, the third hypothesis is given as follows:

H3: After-sale service quality criteria positive impact on the level of customer satisfaction on E-commerce logistics service quality in Viet Nam.

3.5. Staff service quality criteria

According to (Zeithaml and Bitner, 2003), the goods can be produced and then they are sold later, the services cannot. Because the service must be performed and consumed at the same time, the quality of service is highly dependent on the capacity of the service provider, and the quality of the interaction between the service provider and the client. The quality of customer satisfaction will largely depend on what occurs in "real time", including the actions between employees and customers The implication is that delivery employees were asked to adjust their behavior to individual customers to meet customer expectations, hence the first-line service provider have the opportunity to make real-time adjustments not only to the services offered by the company, but also the way in which those services are provided (Czepiel, Solomon, Surprenant & Gutman, 1985). Different customer response their expectations with various types of performances (Bettencourt & Gwinner, 1996:3-20). The change is mainly man-made. Although the machine may malfunction causing a change in service. The service delivery personnel are often a service in the eyes of clients and people can be different in their daily performances therefore ensuring dependable quality of service is a big challenge for the service providers. Quality depends on many difficult factors for the service provider to control, for example, the ability of the consumer clearly shows their needs, ability, or employee motivation to meet those needs, the presence of other customers and the intensity of demand for better service (Zeithaml and Bitner, 2003). According to Zeithaml and Bitner (2003) these challenges revolve around understanding customer service needs and expectations, make provisioning service tangible, deal with countless people and delivery problems, and keeping promises to customers.

Therefore, the fourth hypothesis is given as follow:

H4: Staff service quality criteria positive impact on the level of customer satisfaction on E-commerce logistics service quality in Viet Nam.

3.6. Research model

From the research hypothesis above, the conceptual research model of the impact of logistics service quality on Gen-Z's customer satisfaction: A Case Study on E-Commerce in the Northern Region of Vietnam:

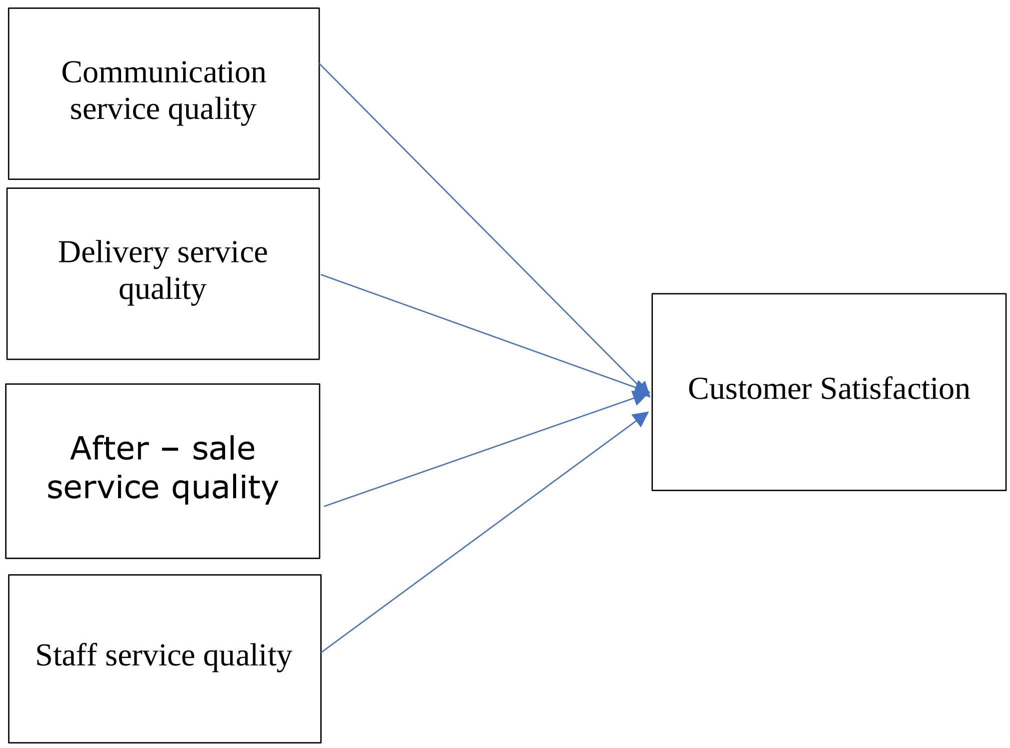

Figure 1: Model of Factors affecting customer's satisfaction (Source: Authors)

4. Research Methodology

4.1. Research Design

The research scale is built based on previous studies [Mentzer et al. (1991); Mentzer and Krapfel (1989); Parasurman and Zeithaml (1988); Zheng (2008); Finch (2007); Ramanathan (2010); JIN Ling – hua et al. (2013); Oliver (1997), Yüksel & Yuksel (2001); Chen & Tsai (2008); Anderson & Srinivasan (2003); Hsu et al, (2012)]. In addition, the authors have expanded upon many elements and observed variables to ensure that the newly developed scale is appropriate for the research environment in the northern region of Vietnam. The focus of the study is on Generation Z online customers.

4.2. Quantitative Research

There are many models of service quality, this is also a research topic that has attracted the attention of people in recent decades (Phan Chi Anh et al., 2013). A survey was conducted to collect data from e-logistics customers in Vietnam. A 5-point Likert scale is used to collect data. Email surveys are preferred, and simple random sampling techniques are used to distribute the questionnaire. However, the sample size is chosen based on inference statistics of Comrey and Lee series (1992). According to this series of articles, "One sample with less than 50 participants would be considered the weaker one; 50 samples would be weaker; 100 samples would be enough; 200 samples were considered good, from 250 to 300 samples were very good. Hence, this study chose a sample size of 300. First, the email ID was collected by different electronic logistics customers. Then the email was generated with the questionnaire, research purpose. help and instructions to fill out the questionnaire.

This study employs online interviews as a method to get data from young clients belonging to Generation Z. The individuals in question are using electronic commerce platforms for the purpose of engaging in shopping activities. The online questionnaire was administered to customers in a random manner after their purchase products on e-commerce platforms. It was conducted online in 2023 with a sample size of 230 respondents. The determination of the sample size in this study was conducted by Hair et al. (2010), who established that a minimum of five observations is required for estimating a parameter. We deliberately employ online surveys as they are accessible to individuals with internet connectivity and can utilize e-commerce platforms. Therefore, these individuals are the specific participants we target in our study. Furthermore, as stated in the Vietnam E-Commerce Report for 2022, the user base in Vietnam is distributed in a particular manner. Specifically, 35% of all e-commerce platform users in Vietnam is Gen-Z generations with the age from 18 to 25 make up the largest share compared to other groups. Hence, directing the survey towards this specific set of respondents in the study can offer significant insights for firms who are either active in or pursuing this region.

Moreover, survey forms were sent to the people who lived in 3 cities in Northern region of Viet Nam are Ha Noi, Hai Phong, Hai Duong. So, they will respond with the fairest view of their satisfaction about E-commerce logistics service quality in Viet Nam. Examining opinions from the people with high level of education will get the results discussed objectively and comprehensively. After collecting the survey responses and check again the result, there are 220 eligible answers that customers who have purchased online before and 10 answers are rejected because they have never online shopping and the efficient was 95.65%.

The final questionnaire has a total of 20 questions, which are further categorized into two different sections. The first section of the questionnaire encompasses all the variables that have influence on consumer satisfaction pertaining to promotional activities on e-commerce platforms. Conversely, the subsequent section focuses on gathering demographic information from the customers.

All the measures in the study employed a 5-point Likert scale. Valid data is analysed through the following steps: (i) Descriptive statistics, (ii) Reliability and validity test, (iii) Exploratory factor analysis, (iv) Confirmatory factor analysis (CFA) and Multi Linear Regression analysis. The scale was built on previous scales including the Communication service quality factor with 3 observed variables (Mentzer et al, 1991; Mentzer and Krapfel, 1989; Parasurman and Zeithaml, 1988; Zheng, 2008; Ramanathan, 2010), the Delivery service quality factor with 4 observed variables (Mentzer et al, 1991; Mentzer and Krapfel, 1989; Parasurman and Zeithaml, 1988; Zheng, 2008; Ramanathan, 2010), the After-sale service quality factor with 3 observed variables (Parasuraman et al., 1988; Zheng, 1988; Jin Ling-hua et al, 2013), the Staff service quality factor with 4 observed variables (Liu et al., 2008), and the Customer satisfaction factor with 3 observed variables (Liu et al., 2008; Oliver, 1997, Yüksel & Yuksel, 2001; Chen & Tsai, 2008; Anderson & Srinivasan, 2003; Hsu et al, 2012).

5. Research results and discussion

5.1. Descriptive statistics

The study obtained data from a sample size of 230 participants using an online survey. The research acquired a total of 220 valid answers, which were selected for inclusion in the analytical model after screening and excluding any missing responses. These 220 responses accounted for 95.65% of the total number of replies received. According to the data, the descriptive statistics below included: In relation to gender, the female population comprises 117 individuals, accounting for 53% of the total, while the male population consists of 103 individuals, representing 47% of the whole. Regarding educational attainment, the most individuals, comprising 139 individuals, possess a university degree, encompassing both graduates and current students (63.5%). Subsequently, the number of individuals who have completed or are currently pursuing a college education stands at 13.3%, while the smallest proportion pertains to high school graduates (4.7%). In terms of income, the most participants (68.6%) fell within the range of above 10 million VND to 15 million VND, with a total of 151 individuals. Conversely, the lowest proportion of participants (3.9%) reported an income below 5 million VND. According to the 2022 Vietnam E-Commerce Report, only 4% of the surveyed individuals under 18 had utilized e-commerce platforms for shopping. Consequently, their lack of experience and perspective hinders their ability to evaluate the survey in an entirely objective manner. Hence, in this study, the author specifically targeted individuals aged 18 and above who have attained a high education to enhance the objectivity and persuasiveness of the survey findings.

5.2. Factor analysis and reliability test

As mentioned in the methodology part, 4 components are the carrier selection decision in the research including communication service quality, delivery service quality, after-sale service quality and staff service quality. Yet, the interpretation indicators (observed variables) of each component are performed through the question survey, that collected from the previous studied and from the theory of each component. Thus, it is crucial to test the rate of the factor in this research in Vietnam E-commerce logistics industry.

Testing the scale in this study, the author using two tools, the EFA factor analysis and the Cronbach's alpha coefficient. Cronbach's alpha coefficient is the tool which used to test the reliability of the scale and to remove the irrational factors. Next, EFA factor analysis is used to test the convergence and favouritism of the scale, also cut down the detected set.

5.2.1. Factor analysis

In this research topic, factor analysis will make deal with the ability to scale down 14 factors to a few components used to calculate the enticement of carrier selection. It also helps check again whether the observed variables in each component are reliable and have the same coherence in the Cronbach's alpha coefficient assurance. The result in the table shows that the value of KMO is 0.728, it quite large. The Bartlett's test with p-value of 0 and it is lower than 0.05. This number above illustrate that observed variables are interact with other and this factor analysis can be used. The method of extracting in the factor analysis of this study is the Principal Component Analysis method with the value of

Eigenvalue more than 1. Because the Eigenvalue index **is** the proportion of the number of extracted information to the amount of information that cannot be extracted when factor analysis, so if the Eigenvalue is less or equal to 1, the rate of the research will not high.

Table 1. Quality of observed variables.

	COMPONENT						
FACTOR	AFTER-SALE SERVICE QUALITY	CUSTOMER SATISFACTION	DELIVERY SERVICE QUALITY	COMMUNICATION SERVICE QUALITY	STAFF SERVICE QUALITY	CRONBACH'S ALPHA	COMMUNALITIES
AQ1	0.926					0.878	0.900
AQ2	0.910						0.868
AQ3	0.746						0.672
CS1		0.856				0.847	0.808
CS3		0.850					0.758
CS2		0.829					0.729
DQ1			0.758			0.771	0.604
DQ2			0.715				0.552
DQ4			0.710				0.551
DQ3			0.612				0.509
CQ1				0.814		0.751	0.740
CQ2				0.760			0.701
SQ1					0.919	0.746	0.872
SQ2					0.661		0.729
TOTAL	3.969	2.203	1.606	1.153	1.060		
% of Variance	28.348	15.738	11.472	8.233	7.574		
Cumulative %	28.348	44.086	55.558	63.792	71.365		
KMO (KAISER – MEYER – ORKIN) Measure of Sampling Adequacy						**0.728**	
Bartlett's Test of Sphericity			Approx. Chi – square				1254.202
			df				91
			Sig.				0.000

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.a

a. Rotation converged in 5 iterations.

According to the result in the table below, 14 variables after EFA analysis were extracted into 2 factors with Eigenvalue greater than 1. We can conclude that these 5 factors explain total 71.365% variation of data.

Next, as the Component Matrix table shown, it is very difficult to find which components explain the factor, therefore it is necessary to pivot the factors. Varimax is the tool carried out the rotation in this research, which minimize the number of variables with large coefficients at the same factor, so enlarge the competence to explain factors. After rotation, variable with factor loading greater than 0.5 can be used to explain a positive factor and other factor smaller than 0.5 can be removed.

The result of calculating the Cronbach's alpha coefficient of the scale of dependent variables and independent variables in the research are showed in Appendix.

The scale of Communication service quality and Delivery service quality with Cronbach's Alpha coefficient received are 0.751 and 0.771 respectively. Corrected Item – Total Correlation of the variable are greater than the requirement is 0.3, so the scale meet the reliability requirement. Moreover, all the components in the scale are possessed.

The score of Staff service quality with 2 factors SQ1 (Image of courteous and friendly delivery staff), SQ2 (Gracious behaviours between delivery staff and customers), all factor in this variable greater than requirement 0.3, so the score of Cronbach's Alpha of this variable is 0.746 and all variables are retained.

The score of After-sale service quality with 3 factors AQ1 (Logistics companies have changing and refund policy), AQ2 (The company accessibility refunding and changing products) and AQ3 (The companies always rapid changing and refunding responses) all factor in this variable greater than requirement 0.3, so the score of Cronbach's Alpha of this variable is 0.878 and all variables are retained.

The scale Customer satisfaction leading to decision making with the Cronbach's Alpha coefficient is 0.847, and all variables are retained.

5.2.2. Multi linear regression

Regression analysis was performed with 1 dependent variable is Customer Satisfaction and 4 independent variables are Communication service quality, Delivery service quality, After-sale service quality and Staff service quality.

The value of the dependent variable is the average value of the observed variables on the decision about satisfaction of the customer in E-commerce logistics service quality in Viet Nam market. The value of the independent variables is averaged based on the component observed variables of independent variables. The result of regression analysis is as follow:

Table 2. Evaluate the suitability of the model.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.746[a]	.556	.545	.50116	2.079

a. Predictors: (Constant), Communication, delivery, after-sale, staff.

b. Dependent variable: Customer satisfaction.

As can be seen in the table, the regression model is relatively consistent with the significance level of 0.05. Adjusted R square = 0.556 means that about 55.6% of variance customer satisfaction are explained by 4 independent variables: Communication service quality, delivery service quality, after-sale service quality and staff service quality. The remaining 44,4% of decision about satisfaction of Vietnamese Gen Z customers in E-commerce logistics quality service is explained by other factors.

The idea of this test is about the linear relationship between the independent variables and dependent variable. The F-test used in the table is a hypothesis test of the relevance of the overall linear regression model. In ANOVA table, the value of sig. = 0.000, so it meets the requirement, and the regression model is suitable for the data set, and it can be used.

Table 3. Factor affecting the level of Gen Z customer satisfaction about E-commerce logistics service quality in Viet Nam.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	1.003	0.355		2.830	0.005		
After-sale	0.258	0.066	0.135	3.891	0.000	0.843	1.186
Delivery	0.148	0.066	0.247	2.251	0.025	0.947	1.056
Staff	0.366	0.071	0.328	5.173	0.000	0.846	1.182

Communication	0.167	0.077	0.133	2.178	0.030	0.913	1.096

a. Dependent variable: Customer Satisfaction.

As can be seen from the table above, the number of sig. coefficient of 4 factors Communication service quality, Delivery service quality, After-sale service quality and Staff service quality are < 0.05 with the detail number is 0.030, 0.025, 0.000, 0.000 respectively, | t | > 2 and equivalent to 95% reliability, means that all these factors have impact on the level of customer satisfaction in E-commerce logistics market.

Also in the table, we can see that there are two types of coefficients are: Standardized and Unstandardized. In standardized coefficient (Beta), it used to normalize variables, so it also used to compare the level of impact of independent variables with variables depend. Independent variable which has higher amount beta coefficient, it also has greater impact on dependent variables. Another result in the model is the Scatterplot graph, it showed that the residual disperses in an area around the path through 0 bus does not form a shape. So, the remainder and the predicted value are independent, while the variance of remainder unchanged. Thus, the regression model is suitable.

Finally, there is a step need to check is multicollinear phenomenon, it means that independent variables have no correlation between other. Normally, checking this phenomenon, they need to use VIF index (Variance Inflation Factor), and if the amount of the VIF of each independent variable is smaller than 10, independent variables have no phenomenon of multicollinearity. According to the regression result table, all independent variables are smaller than 10, so the model does not take place multicollinearity phenomenon.

Based on the coefficients table above, we have the following regression equation:

$$CS= 1.003 + 0.167*CQ + 0.148*DQ + 0.258*AQ + 0.366*SQ$$

To describe the result table, we focus on the beta score of standardized coefficients, the sort order from the highest to the smallest number of Beta score is 0.328 – staff service quality, 0.247 – delivery service quality, 0.133 – communication service quality and 0.135 – after-sale service quality. It was clear that young Vietnamese customer paid the most attention to staff service quality because, the staff is the people who they meet when receive order and the demand about the quality of the manner of the staff is very important. Not only the customer buying the good for one time, the manner of the staff with the customer affects a lot to customer loyalty and the next time online purchase order. Also, the second thing that the customer attend about their satisfaction is delivery service quality, when they purchase an online order, they need to wait for a period to receive their products, so they really dissatisfy with the problems such as wrong goods, their products broken or their good packed carelessly. Next, communication service quality and after-sale service quality are two points that have the score close to each other. With communication service quality, the customer wants the providers react with their inquiries soon and proactively answer their questions about the goods or policy when their products have problems; in after-sale service quality, when their products have problems with packing process or the provider send to them wrong products, they want the provider change or refund for them quickly. But recently, in Vietnam, the problem about wrong products or broken products is improving significantly. So, this issue ranks behind staff service quality or delivery service quality of concern are also understandable.

We can conclude that the level of Gen Z customer satisfaction for e-commerce logistics services in Vietnam is still relatively low, especially about staff service quality and delivery service quality of the E-logistics companies which using the high – end technology to support the customers. The findings of this study align with the World Bank's research reports on the Logistics Performance Index (LPI) in Vietnam spanning from 2018 to 2023. Despite the favourable growth projection for the e-commerce business in Vietnam, the quality of logistics services in the country has exhibited a drop over the previous five years. According to Logistics Performance Index (World Bank, 2023), Vietnam's overall LPI score is 3.3, placing it 43rd out of 140 countries and territories worldwide, as indicated by the LPI 2023 index. In 2018, Vietnam's overall LPI score was 3.44, which placed it in the 39th position compared to the data report. To be more precise, Vietnam's Logistics Compatibility and Quality Index in 2023 was merely 3.2, placing it at the 53rd position out of 140 countries and territories on the list. In 2018, Vietnam's Logistics Competence and Quality indicator scored 3.4 points, placing it 33rd in the ranking. Over the previous five years, Vietnam's Logistics Competence and Quality rating has declined by 20 positions, suggesting a significant deficiency in the quality of highly skilled human resources employed in Vietnam's logistics sector. Furthermore, based on the assessment, Vietnam's Logistics Shipment Index in 2023 was positioned at the 49th spot out of a total of 140 nations and territories, with a corresponding score of 3.16.

These are the shortcomings of Vietnamese businesses compared to the logistics industry of the world. Compared to some countries around Vietnam in the LPI index of the same year, China's LPI index in 2023 was 4.0 ranked 7th, with International Shipment score and Logistics Quality & Competence score are 4.0 ranked 2nd and 4.0 ranked 11th among 140 countries and territories worldwide, respectively; Taiwan’ LPI index in 2023 was 3.9 ranked 13th, with International Shipment score and Logistics Quality & Competence score are 3.7 ranked 8th and 3.9 ranked 14th among 140 countries and territories worldwide, respectively. The findings of this study align with previous research conducted in China, which also found that customer satisfaction in online shopping is not influenced by the quality of after-sale services (Yen et al, 2022). In contrast, the researchers observed a contrasting outcome in Taiwan, attributing it to disparities in the return policies of e-commerce logistics markets between China and Taiwan. Furthermore, the researchers suggest that the inflexible profit-oriented mindset in China may hinder sellers from implementing cost-generating restrictions. In the current context of globalization and industrial revolution 4.0, when large corporations are expanding the market share of business investment into developing countries like Vietnam, that will be a huge challenge for domestic businesses if they want to survive and compete fairly with them. This phenomenon is also seen in the research conducted on satisfaction and loyalty within the e-commerce context of Malaysia and Qatar (Hung et al, 2022).

6. Implications and recommendation

This research aims to provide a comprehensive set of criteria for evaluating the quality of e-commerce logistics services, with a specific focus on its impact on customer satisfaction among Vietnamese Generation Z customers who live in 3 big cities in the Northern region are: Ha Noi, Hai Phong, and Hai Duong. Simultaneously, it is evident that there exists a disparity in the quality of e-logistics services across various genders and economic levels within Generation Z. The findings of this research have significant practical consequences for online retailers that want to enhance the quality of their logistical services while addressing Generation Z. Logistics providers should prioritize their attention towards the major assessment criteria that have been determined, which include timeliness, accessibility, order correctness, order condition, order discrepancy management, and customized service. In order to enhance these facets, potential measures that can be adopted include the implementation of strategies to optimize warehouse and fulfilment procedures, the expansion of pickup and drop off alternatives, the implementation of accuracy checks prior to delivery, the utilization of automation and barcode or QR code scanning technologies, the improvement of packaging methods, the establishment of comprehensive reporting mechanisms, prompt resolution of order-related concerns, and the provision of personalized services. In addition, it is essential for E-commerce logistics providers to enhance their compensation and return policies to address the challenges faced by clients throughout their engagement with promotional initiatives. It is important to ensure the explicit protection of customers' interests under the policy governing third-party involvement in physical distributions. From the perspective of consumers, those belonging to Generation Z who have been exposed to contemporary technology will have no difficulties when it comes to purchasing or engaging with e-commerce platforms. Nevertheless, it remains essential to thoroughly evaluate and comprehend pertinent details pertaining to promotional initiatives or merchandise, alongside associated rights and rules, prior to engaging in transactions or partaking in promotional activities. Furthermore, by using contemporary technology, such as social media and communication platforms that are preferred by individuals belonging to Generation Z, it is possible to enhance client trust and pleasure. Enhancing the quality of logistics services in this manner would confer a competitive edge and enhance the capacity of online retailers to sustain long-term client loyalty among Generation Z.

The findings of this study have made a significant contribution to enhancing the research framework pertaining to consumer satisfaction in the context of e-commerce logistics service quality within the Northern Vietnamese market. Numerous prior research has discovered various characteristics that exert effect, including service quality, dependability, responsiveness, security, and payment. Future research may be conducted by the writers to explore novel aspects or investigate variations in demography that impact customer satisfaction also in other region of Viet Nam and other countries in Asia region with different generalizability of customers.

Furthermore, it is important to do research on an e-commerce platform also e-commerce logistics providers, such as Shopee or Lazada, to examine client habits and levels of satisfaction. This will enable the formulation of appropriate suggestions for a specific e-commerce logistics service strategy.

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SMEs Strategic Behaviour: Implication on Their E-Commerce Adoption And Cuctomer Responsiveness

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INTRODUCTION

This study aims to establish the linkages between the strategic behaviour of SMEs, their e-commerce adoption and their customer responsiveness. The Ghanaian SME landscape has become very competitive particularly in the services sector. Survival in the sector requires firms to be customer responsive and to possess ecommerce capability. The need to be customer responsive and possess ecommerce capability has therefore become a growing phenomenon among SMEs in Ghana (Iddris, 2012). Whilst some SMEs are exploring the paths to ecommerce and achieve responsiveness, others appear unrattled by these developments. It is therefore of research interest to establish whether the observed behavioural patterns among the Ghanaian SMEs sector is emerging from the strategic orientations of these firms.

The Miles and Snow typology is employed as the foundation for exploring the SMEs strategic orientations. The motivation for the study was driven by the evidence from the literature that, the operations strategy literature has predominantly focused on the operations strategy of large firms (Eckert & Gatzert, 2019; Garavan et al., 2019; Huang et al., 2015; Sahoo, 2020; Wong et al., 2020), to the neglect of SMEs. SMEs operations strategy has not been sufficiently explored in the literature hence, the need for improved understanding of SMEs' strategic behaviours.

Oluchukwu, Donatus, & Franca (2019) argue that, a firm's strategies provide models and ideas which help to recognise and discern opportunities that add-value to customers. Excellent customer intimacy is all-important for the complete effectiveness of a concealed champion approach. Several studies have validated the Miles and Snow typology as an appropriate theory for studying strategic behaviour of firms (Akingbade, 2020; Grimmer, Miles, Byrom, & Grimmer, 2017; Yanes-Estévez et al., 2018). Similarly, Miles and Snow's typology has been employed in studies including e-commerce (Carmichael, 2017; Kumar, Fuksa, & Kumar, 2018) because it is premeditated to apprehend and integrate organisational culture into a strategic framework.

E-commerce is known to make significant contributions towards economic development of developed countries, enhancing the competitiveness of firms coupled with offering new thriving scopes. E-commerce deals with trading goods or services to users directly from a vendor's website or a virtual trading hub (Jain et al., 2021). E-commerce has been examined in the literature within the context of its contribution to competitive advantage (Hamad, Elbeltagi, & El-Gohary, 2018; Lestari, Muhdaliha, & Putra, 2020; Xuhua, Elikem, Akaba, & Worwui-Brown, 2019); the opportunities offered to businesses (Khan, 2016; Rahayu & Day, 2017) (Tu & Shangguan, 2018) and the factors affecting it's adoption (Ocloo et al., 2018).

Customer responsiveness places premium on a firm's proficiency to react to customer's concerns and address them swiftly. Customer responsive firms benefit from lead time reduction, inventory management and agility (Carmichael, 2017; Kumar, Fuksa, & Kumar, 2018). Customer responsiveness upturns firm consciousness of the innovation opportunities that develop within technologically unsettled settings. A firm's strategies provide models and ideas which help to recognize or discern opportunities that add-value to customers. However, to remain competitive, firms need to analyse their customers' needs and be responsive to them.

SMEs are important economic development agents as they represent on average, about 95% of all firms in every economy. Understanding SMEs strategic orientations is imperative towards improving their performance. However, less research attention has been paid to SMEs' strategic behaviour and its relationship with e-commerce adoption and customer responsiveness. The current research is initiated in response to understanding the extent to which Ghanaian SMEs' strategic behaviour (using Miles and Snow's typology of strategies) influence their adoption of e-commerce as well as their capacity to be customer responsive. This study contributes to developing knowledge and improving understanding of the operations strategy of SMEs in the extant literature which is woefully limited.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The Technology-Organizational-Environment (TOE) theory and Theory of Reasoned Action (TRA) are employed to provide the theoretical foundations for the study. The TOE theory is the first in the technology adoption literature that recommends a non-specific set of factors that enlighten and envisage the possibility of innovation adoption (Awa & Ojiabo, 2016). Also, adoption is an attitude issue. TRA on the other hand, is a strong theory to guide information system's technological innovation adoption. Since the current research has the objective to analyse the relationship between firms' strategic behaviour, customer responsiveness and e-commerce, these theories provide sound theoretical foundations.

Strategic Behaviour of Firms, E-commerce and Customer Responsiveness

Miles & Snow (1978) suggested that firms in broad-spectrum develop fairly stable forms of strategic behaviour in order to realise a good orientation with the apparent environmental settings. They centred their typology on three sets of problems challenging every firm: entrepreneurial (the choice of products and markets), engineering (the choice of technologies for production and distribution) and administrative (the choice of areas for future innovation and rationalization of existing structure and processes). Four different strategies are defined by the authors for firms. These are; prospectors, defenders, analysers and reactors. A firm may be identified as a prospector, defender, analyser or a reactor depending on how it approaches the three problems that challenge the firm.

Analyser

Firms that pursue the analyser strategy jump unto a new innovation only after success has been demonstrated for that particular innovation. Analysers according to Lin, Tsai, & Wu (2014), avoid the risk that occur in Defender and Prospector and take advantage of Defender and Prospector by connecting their essential competences. Analysers are evident in businesses that work in two types of product-market areas: relatively stable and permanent change. Analysers endeavour to control risks while exploiting opportunities (Miles & Snow, 1978). Klinger et al. (2019) also opine that Analysers are purposefully exploratory in nature. The Analyser makes effort to discover new products and venture into new market opportunities while concurrently preserving the firm's principal traditional products and customers. Analysers are slow to reacting to changes in dynamic or competitive markets (Carmichael, 2017). Based on this argument, the following hypotheses are proposed:

$H_{1a:}$ The pursuit of the analyser strategy influences SMEs' adoption of e-commerce.

$H_{1b:}$ The pursuit of the analyser strategy inhibits SMEs' customer responsiveness.

Defender

Organizations that exhibit the defender strategic behaviour pay attention to growth of new products through an orthodox means. They typically contend on quality and price other than new markets or products and concentrate on revamping the competence of their present processes. Hawrysz (2020) posits that Defenders take on a lot of proper scheduling, gather and scrutinise huge volumes of records on service necessities, appraise alternatives to meet those necessities, and custom progressive procedures to balance the costs and benefits of each choice. Defenders provide exceptional services to customers

(Lumbantoruan & Pujangkoro, 2020). They are therefore likely to adopt e-commerce because, it is an approach that helps reduce operating cost whiles maintaining existing customers. Efficiency is a key factor to their operations. Due to the exceptional services they provide to their customers, they are also likely to be attentive to the needs of their customers hence, the following hypothesis is proposed:

H_{2a}: The pursuit of the defender strategy influences SMEs' adoption of e-commerce.

H_{2b}: The pursuit of the defender strategy influences SMEs customer responsiveness.

Prospector

Firms that pursue the prospector behaviour are innovative and technology inclined and are concerned with human resources more than any other resource. Prospectors are firms with flexible non-formal organizational structure that always look out for new market opportunities; innovation processes and new product development. They are creators of change and high-level risk takers (Yanes-Estévez et al., 2018). The positive and antagonistic market stands taken by prospectors supports thriving in markets characterised by high level of vitality or race hence the likelihood to adopt e-commerce (Carmichael, 2017). Prospectors struggle in being operational as insecurity surges and with focus on product and technology innovation, there may be less likely to be efficient in responding to customers' changing demands (Chaimankong & Prasertsakul, 2012). Based on this argument, the following hypotheses are proposed:

H_{3a}: The pursuit of the prospector strategy influences SMEs' adoption of e-commerce.

H_{3b}: The pursuit of the prospector strategy influences SMEs customer responsiveness.

Reactor

Firms that pursue the reactor strategic behaviour do not have a clearly defined strategy for their organization (Aleksic & Jelavic, 2017). The organization maintains a current strategy-structure relationship despite overwhelming changes in environmental conditions (Klinger et al., 2019). Reactors are greatly exposed to adopting e-commerce, but their adoption is grounded on their acknowledgement of modifications in their industry towards grander execution of technology. They are likely to adopt e-commerce in as much as it would profit their operations but not as a result of technological innovation. Even those who have employed e-commerce apply technology either to develop their operations or because of the varying requests of customers, which indicates a reaction to altering changing aspects relatively than a practical stance on technology (Carmichael, 2017). Reactors will not orient with either market vitality or competitive force in a significant way (Carmichael, 2017). This implies that Reactors may not be responsive to the changing needs of their customers hence, the following hypothesis is tested:

$H_{4}a$: The pursuit of the reactor strategy inhibits SMEs' adoption of e-commerce.

$H_{4}b$: The pursuit of the reactor strategy inhibits SMEs' customer responsiveness.

This study analyses the strategic behaviour of SMEs and the impact this has on SMEs' customer responsiveness and e-commerce adoption propensity. Subsequently, the independent variables for the study are strategic behaviours of firms, while customer responsiveness and e-commerce adoption are the dependent variables. Employing the (Miles & Snow, 1978) typology, SMEs may be orientated towards being Prospectors, Defenders, Analysers or Reactors.

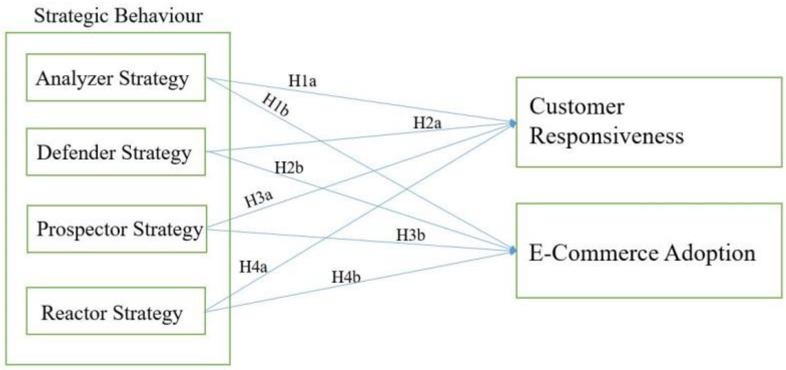

Figure 11 Conceptual Framework

RESEARCH METHODS

The study adopted the quantitative approach to gather data from 348 SMEs in the Information and Communications, Administrative and Support Services and Fashion subsectors of the Services sector in Ghana. The targeted respondents were either owners, managers or proprietors of their firms. The research variables were measured using a 5-point Likert scale with the measurement items being largely adapted from literature. Out of the 348 questionnaires distributed, 300 responses were valid for analysis representing 92% response rate. This response rate according to Lindemann (2021) is acceptable for analysis since it is above the acceptable average rate of 50%. The Partial Least Square Structural Equation Modelling (PLS-SEM) was employed in the analysis of the structural relationships among the research variables.

ANALYSIS AND RESULTS

The analysis of the relationships involved two steps: first, the evaluation of the measurement model and second, the structural model assessment (Hair *et al.,* 2017). The measurement model was evaluated to know the reliability and validity of the study constructs' measures. The internal consistency of the variables was measured using indicator reliability. The rule of thumb is that, an indicator is reliable if the outer loadings estimated is 0.70 and above. However, loadings between 0.40 and 0.70 should be maintained if their removal will bring about a reduction in the composite reliability and the average variance extracted of the corresponding construct (Hair Jr et al., 2016). Subsequently, indicators that did not meet the threshold of 0.70 were deleted from the model, thus, Reac 1 and Reac 3. Anal 5, Defe 2, Pros 1, Reac 2 were items with loadings lower than the threshold of 0.70 but were retained since their exclusion negatively disturbs the composite reliability. The Cronbach Alpha and composite reliability for all the study constructs were above 0.70. The analysis therefore established that, all the constructs achieved the acceptable levels of internal consistency indicating acceptable levels of reliability.

In testing for the validity of the study constructs, convergent validity and discriminant validity were considered. The convergent validity was evaluated using the Average Variance Extracted (AVE) of the constructs. The rule of thumb with respect to evaluation of convergent validity is that, the AVE should be above 0.50 (Hair *et al*., 2017) to be acceptable and this is because the constructs should be capable to explain more than 50% of variations of the various indicators. All the study constructs met the threshold with the AVE values ranging between 0.629 to 0.750 to indicate the presence of sufficient convergent reliability. The discriminant validity of the constructs was assessed by employing the Fornell-Larcker criterion. The threshold for Fornell-Larcker criterion is the values being equal to 0.50 or greater. The square root of the AVEs of the constructs are higher than all of the diagonal AVEs of the other constructs and the AVE values were all greater than 0.50 depicting that all the constructs met the criterion.

The evaluation of the structural model involved assessment of multicollinearity, significance of path, coefficient of determination, effect size, predictive relevance and model fitness all of which met the minimum threshold requirement. Emphasis in this paper is placed on the path significance which describes the relationships between the research variables. Table 1 shows the assessment of the path significance.

Table 11 Assessment of Path Significance

	Path	Path Coefficient	P Value	T-statistics	Decision
H1a:	Anal -> Ecom	0.159	0.001	3.202	Significant
H1b:	Anal -> CusR	0.02	0.771	0.292	Not Significant
H2a:	Defe -> Ecom	0.257	0	5.269	Significant
H2b:	Defe -> CusR	0.102	0.084	1.734	Not Significant
H3a:	Pros -> Ecom	0.233	0	4.54	Significant
H3b:	Pros -> CusR	0.181	0.002	3.055	Significant
H4a:	Reac -> Ecom	0.032	0.658	0.442	Not Significant
H4b:	Reac -> CusR	-0.009	0.91	0.113	Not Significant

5% significant level, two-tailed test. (Anal= Analyser; Defe = Defender; Pros = Prospector Reac = Reactor; Ecom = E-commerce adoption; CusR = Customer Responsiveness)

The hypothesised relationship h1a between analyser strategy and e-commerce adoption, showed a statistically significant relationship. Also, for H1b, analyser strategy and customer responsiveness a non-significant relationship was identified. The path relationship hypothesised for H2a: defender strategy and e-commerce adoption, a significant relationship was established. The path relationship hypothesised for H2b: defender strategy and customer responsiveness, a non-significant relationship was identified. The path relationship hypothesised for H3a: prospector strategy and e-commerce adoption, a significant relationship was established. The path relationship hypothesised for H3b: prospector strategy and customer responsiveness, a significant relationship was established. The path relationship hypothesised for H4a: reactor strategy and e-commerce adoption, a non-significant relationship was identified. Finally, the path relationship hypothesised for H4b: reactor strategy and e-commerce adoption, a non-significant relationship was established.

FINDINGS AND IMPLICATIONS OF THE STUDY

The results demonstrates that, the analyser strategy has a positive and significant relationship with e-commerce adoption. This finding implies that SMEs pursuing the analyser strategy are likely to adopt e-commerce in their business operations. This evidence confirms the findings from (Feyissa & Sharma, 2017) who established that analysers engage in innovative activities such as product development and market diversification. e-commerce adoption by these organizations is compatible with their innovative business processes. The finding also confirms the theory that analysers are responsive to innovation and are efficient at their operations (Lin et al., 2014). The results also reveal that indeed, the analyser strategy does not influence customer responsiveness, thus supporting $H1_{b.}$ This finding confirms the finding of (Carmichael, 2017) who established that analysers react slowly to the changing needs of their customers in competitive markets. The evidence of slow reaction has confirmed the knowledge that, analysers and customer responsiveness do not relate. They encounter the ineffectiveness of defenders and inefficiencies of prospectors if they fail to administratively differentiate structures and processes that support both stable operations for the core business and innovation in rapidly changing markets. This challenge can also have an effect on their response to their customers as a whole Pudenz, 2019).

The result demonstrates that the defender strategy has a positive and statistically significant relationship with e-commerce adoption, suggesting that SMEs pursuing the defender strategy are potential adopters of e-commerce. Defenders habitually administer their products or services to an openly distinct market (Hawrysz, 2020). The hypothesis $H2_b$ shows a positive but insignificant relationship. This means that the relationship between defender strategy and customer responsiveness is not statistically supported. Hence the alternative hypothesis was accepted to mean that, the pursuit of a defender strategy will not influence customer responsiveness. This finding contrasts with earlier studies (Hawrysz, 2020; Lumbantoruan & Pujangkoro, 2020) which agree that defenders put prominence on their customers.

The results further revealed a positive and statistically significant relationship between the prospector strategy and e-commerce adoption. The characteristics of the prospector strategy aligns well with e-commerce hence this finding not surprising; Prospectors are likely to adopt e-commerce. This result supports existing literature (Cassol, Lorandi, Carvalho, Cintra, & Ribeiro, 2019; Chaimankong & Prasertsakul, 2012; Yanes-Estévez et al., 2018) that prospectors are technology driven and innovators and influencers of e-commerce adoption. With regards to customer responsiveness, $H3_b$ (The pursuit of the prospector strategy influences SMEs customer responsiveness) was supported because the results revealed a positive and statistically significant relationship (Chaimankong & Prasertsakul, 2012). Prospectors are proactive in addressing customer's changing needs without considering the associated cost, thus, making the prospector strategy a customer-focused strategy.

$H4_a$ proposed that the pursuit of the reactor strategy inhibits SMEs' adoption of e-commerce. The test of this hypothesis proved a statistically positive but insignificant relationship (p-value = 0.658, path coefficient = 0.032). The finding supports Klinger et al., (2019) who established that a reactor firm upholds a current strategy-structure relationship in spite of the vast changes in their operational environmental conditions. $H4_b$ which states that, the reactor strategy inhibits customer responsiveness was partly supported because the results revealed a negative but and statistically non-significant relationship between the reactor strategy and customer responsiveness. This finding is in agreement with Griffith et al., (2012) who posit that, knowledge acquisition for reactors is modest, and at best without rigorous efforts and their ability to make use of prevailing knowledge is either disregarded or taken the wrong way, in addition to being unable to efficiently apply any knowledge attained to reduce cost.

The combined effect that firms' strategic behaviour has on e-commerce adoption (0.156) and customer responsiveness is weak (0.043) since both R^2 values are less than 0.25. Following the recommendations of Hair, Ringle, & Sarstedt (2011), R^2 values of 0.75 and above represent substantial, 0.50 represents moderate, whilst 0.25 and below represents weak effect.

CONCLUSIONS OF THE STUDY

The study concludes that within the Ghanaian context, strategic behaviours based on Miles and Snow taxonomy of analysers, defenders and prospectors have a significant positive influence on SMEs propensity for e-commerce adoption whiles reactors do not have a significant influence on e-commerce adoption. This means that firms adopting the analyser, defender and prospector strategies are likely to adopt ecommerce business model to enhance their performance.

The study has further established that, the analyser, defender and reactor strategies do not promote customer responsiveness whereas the prospector strategy influences customer responsiveness. Thus, firms intending to achieve high levels of customer responsiveness may consider a shift in strategy to favour the prospector strategy. This study has justified that indeed the behavioural intention to adopt a technology is influenced by attitude and societal influence (Sharma & Mishra, 2014). This study has also advanced literature that strategic behaviour (using Miles and Snow typology) has structural relationships with SMEs propensity to be customer responsive and their adoption of e-commerce.

The study may be among the first to establish the linkages between Miles and Snow's typology, customer responsiveness and e-commerce adoption among service SMEs in a developing country context where literature is lacking. The findings of the study educate managers to know that strategies of firms though complex are necessary evil for the survival of a firm. Therefore, Ghanaian entrepreneurs need to know how to respond strategically to their changing business environment and develop business models and strategies that will help them to be competitive, a process underpinned by firms' competitive strategy.

LIMITATIONS OF THE STUDY

The data gathered for the study was from three selected service sub-sectors hence this affects the generalisability of the study for all service sector firms in Ghana. Future studies could further explore the Miles and Snow's typology in other service sectors such as Real Estate, Education, Social Work and other service activities where the typology seem equally relevant. Also, future studies using the same Miles and Snow's typology can verify what impact the strategic orientation of a firm has on the performance of the firm using a mediator (e.g., firm's age or size). Also, a study on the impact of strategic behaviours of firms on profitability of firms may look promising.

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Exploring the Barriers and Identifying Strategies for Express Courier Services in Using Crowdsourced Last-Mile Delivery (CSLMD)

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INTRODUCTION

The concept of crowdsourcing evolved over the years with the continuous advancement of technology, consumer demand, consumer expectations, and the willingness of the crowd to participate in economic activities. Crowdsourcing is the practice where a task originally performed by a company employee is awarded to an unspecified group of individuals through an open call (Mangiaracina et al., 2019). The concept of "crowdsourcing" was introduced by Jeff Howe, a journalist, in 2006 (Ikediego et al., 2018). Crowdsourcing became popular in the late 2000s with the rise of ride-sharing platforms such as Uber and is currently being used in a wider range of industries such as hospitality, finance, delivery, and retail each with distinct goals to achieve. Crowdsourced logistic services are currently a trend in the developing stage (Gläser et al., 2021). Crowdsourced last-mile delivery (CSLMD) is currently popular in parcel delivery except in the courier industry and it is interesting to identify the reasons for this difference. This is the research gap aimed to fill by this research.

With the purchasing patterns shifting from in-store to online an increased demand was created in the market for fast and economical supply chain solutions which were later fuelled by the COVID-19 pandemic. This resulted in an increase in the number of delivery vehicles on the road causing negative externalities such as increased traffic congestion, pollution levels, and transportation costs ultimately impacting the increase in last-mile delivery costs and decrease in service levels (Guo et al., 2019). The convenience, anticipation, and flexibility brought by e-commerce created a unique demand for fast, low-cost, sustainable, and efficient last-mile deliveries rather than simply fast deliveries (Ghaderi et al., 2022, Rechavi and Toch, 2022). This shift in demand dynamics created a service gap in last-mile delivery calling for an innovative last-mile delivery solution that is more effective, cheap, sustainable and faster than conventional delivery methods. In response, termed crowd logistics, parcel delivery using crowdsourced agents was introduced as a practical solution in the retail industry (Vakulenko et al., 2019). Since then, crowd logistics has become a popular method of last-mile delivery in retail trade, e-commerce, food delivery, and home deliveries (Lim et al., 2018) but is less popular in the courier industry. Due to this, crowdsourced delivery and related concepts attracted a growing interest among supply chain scholars due to its benefits such as optimization of resource utilization, reduced costs, reduced emissions, and better fostering of customer relationships compared to traditional LMD (LMD) which is having a dedicated fleet (Carbone et al., 2017, Vincent E. Castillo et al., 2021, Li et al., 2019).

For this research CSLMD can be simply identified as employing the crowd to perform last-mile delivery (Ghaderi et al., 2022). The supply chain industry is an industry offering a wide range of services including express courier. Using a variety of modes of transportation, the express courier industry handles both domestic and international parcels and goods to guarantee a time-definite delivery. (UNStatisticalDivision, 2015). In the journey of a parcel from the origin to the destination LMD is identified as an important yet most expensive operation due to the customized service level it has (Mangiaracina et al., 2019). This research is limited to CSLMD in the express courier industry.

Amazon Flex is a global crowd-sourced delivery initiative by Amazon group which can be identified as one of the most successful applications of CSLMD(Wang et al., 2023). Several other examples of CSLMD are DoorDash, UberEats, PickApp, Deliv, Instacart, FriendShipper, and Walgreens (Carbone et al., 2017, Vincent E. Castillo et al., 2021). Uber Freight crowdsources the entire supply chain, not just last-mile delivery. An interesting observation here is that these applications are parcel delivery services but not express or courier companies. The only industry example for CSLMD is Roadie, a crowdsourced delivery platform currently owned by United Parcel Services (UPS) (Roadie.com, 2023). Pilot projects such as DHL BringBuddy, DHL Myway (Buldeo Rai et al., 2017), and DHL Parcel Metro (DHL.Com, 2018) were implemented by DHL around the world. However, due to a lack of continuity, the success of these as business practices is doubtful (Guo et al., 2019, Rechavi and Toch, 2022).

It is established that CSLMD is successful in parcel delivery context when delivery is the only task and is performed in isolation (Ghaderi et al., 2022). In the courier industry, last-mile delivery is a crucial activity. However, this operation can be slightly complex, and there are other challenges around it. Logisticians anticipate that crowdsourced delivery will have a high impact in less than five years as a sharing economy concept (Nieto-Isaza et al., 2022). This study first aims to explore the challenges faced by the express courier industry when using crowdsourced last-mile delivery. Secondly, it aims to develop strategies to overcome these challenges.

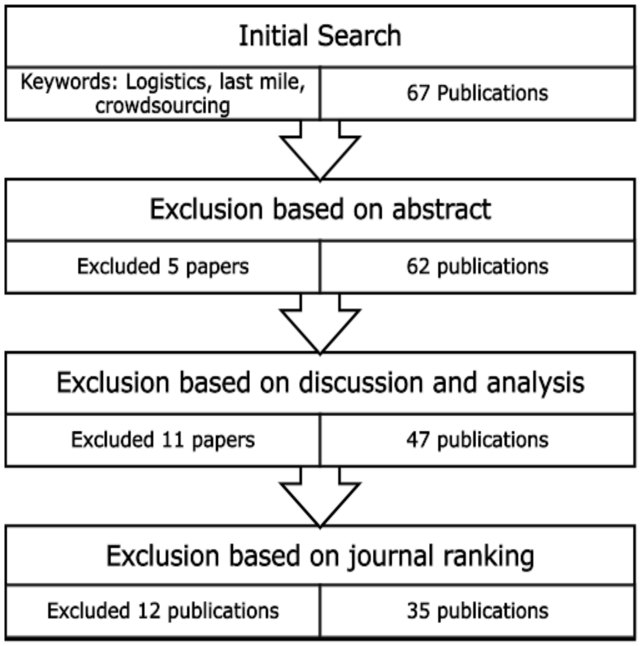
SIGNIFICANCE OF THE STUDY

Crowd-based delivery solution allows sharing of cost, resources, time and information among a large crowd providing time efficient and cost-effective deliveries due to shorter trips and lesser packages per delivery ride (Seghezzi and Mangiaracina, 2022). Despite these benefits, there is still lack of comprehensive research explaining why the express courier sector hasn't fully adopt CSLMD. Given the successes of various initiatives like Amazon Flex and Uber focused on end-to-end parcel delivery, alongside crowd-sourced courier services such as Roadie, there is a pressing need to assess the potential for integrating crowdsourcing into express courier services. The advantages of crowdsourcing are not limited organisational benefits but have a multiplier effect on the economy, the customers, and the crowd (Saglietto, 2021). This study is aimed at addressing this research gap. The aim of this study is to identify the challenges for the express courier industry in implementing CSLMD and present strategic solutions to overcome those challenges making CSLMD industry friendly.

METHODOLOGY

This qualitative research involves three stages, combining interviews and systematic literature reviews. Initially, a literature review is conducted to identify the current literature related to CSLMD and to develop the interview questions. Based on the findings from this initial review, interviews are then carried out. Following the interviews, a second literature review is performed to explore existing literature for suitable solutions and strategies for the successful implementation of CSLMD. This paper outlines the findings of the initial literature review which is an in-depth evaluation of CSLMD. Researching a mature topic that require reconceptualizing of literature or researching an emerging topic requiring synthesis of literature to identify themes, key constructs and arguments is identified as a suitable occasion to conduct an integrative literature review (Torraco, 2005). Further, for an impactful integrative review, identifying the space and boundaries of the review are equally important (Elsbach and van Knippenberg, 2020). Accordingly, in this review the timeline of the publications, types of publications and theoretical or conceptual frameworks were defined as the boundaries.

This research is primarily focused on a very niche field which is CSLMD within the express courier industry. To collect information on this topic, several indirect and deductive search terms around the main scope were used keeping LMD and crowd sourcing as the central focal points. To maintain the high-quality in literature Scimago Journal rank (SJR) quartiles Q1 or Q2 during the past three years were used as the quality indicator.



Both journal articles and conference proceedings extracted from academic databases accessed via Edith Cowan University are used. Initially 61 publications were identified with in the setting of logistics, LMD and crowd sourcing. The exclusion and inclusion process are displayed in Figure 1.

Figure 1 Literature review process

The theoretical framework for this study centres around Business Model Innovation (BMI). BMI can be defined as "designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi, 2017). In the context of an express courier company, introducing a novel approach like crowdsourcing to address challenges in the last mile delivery can be achieved through BMI. BMI consist of three umbrella business models: value offering, value architecture, and revenue model (Brenk et al., 2019, Arnold et al., 2016). In the examination of the barriers faced by the express courier industry in Sri Lanka regarding the adoption of CSLMD, this study discovered a total of 11 challenges and 13 solutions. Accordingly, the theoretical implication features an advancement of the identified solutions under the three BMI dimensions.

LITERATURE IDENTIFIED

Initial studies on crowdsourcing have explored the feasibility of using crowdsourcing for different logistics activities such as inventory management (Gurtu and Johny, 2019), demand forecast and LMD (Ha et al., 2022). As the cost of LMD and customer demand for low-cost, fast, efficient, and sustainable delivery solutions increased more scholars gave attention to LMD. Initially studies were focused on delivery efficiency under which, scholars paid attention to optimizing traditional delivery methods through investigating the vehicle routing problem (Geetha et al., 2013, Ramirez-Villamil et al., 2020). Later, the focus diverted to innovative LMD solutions under which concepts such as crowdsourcing (Carbone et al., 2017), parcel lockers (Ghaderi et al., 2022), drones (Boysen et al., 2018) and dynamic pricing were studied. The Preliminary identification of papers for this review are within this latter focus. Seghezzi et al (2021) present a third focus area which is identifying alternative solutions to traditional delivery methods.

LMD is the only occasion a logistic service provider interacts with the consignee in person and therefore this interaction generates monetary and non-monetary benefits such as brand visibility, trust and customer relationships. Therefore, innovative LMD solutions can impact this relationship. LMD however is the most expensive yet least efficient function in the supply chain (Lim et al., 2018, Johnson and Chaniotakis, 2021). This operation has more dispersal destinations and less packages to be delivered in a tight time frame compared to other stages of the supply chain process which has more consolidation and synergies (Mangiaracina et al., 2019) making it expensive. However, due to high intangible nature of logistic services customers often struggle to comprehend it (Guo et al., 2019) and therefore, are not willing to pay higher prices for LMD (Moncef and Dupuy, 2021). All things considered, managing the LMD for any logistics service provider is very important to achieve economic, operational, and sustainable benefits for its continuity. By using innovative delivery methods like crowdsourcing, express courier companies can achieve efficient and effective LMD management.

The field of last mile research remains disjointed and relatively incoherent primarily because of the contributions from various disciplines and standpoints (Ha et al., 2022, Lim et al., 2018, Moncef and Dupuy, 2021). Majority of the literature on crowd logistics are high performing quantitative analyses (Seghezzi and Mangiaracina, 2022) aimed at developing a general framework around benefits, characteristics, limitations and different CSLMD application methods (Seghezzi et al., 2021). On a distinct perspective it was observed that literature was developed around CSLMD via occasional drivers, with transfers between couriers and two-tiered crowdsourcing (Wang et al., 2023). Literature on Business to Customer (B2C) e-commerce LMD has been mainly focusing on three key areas namely environmental sustainability, effective customer service and the cost efficiency (Mangiaracina et al., 2019). Over the past decade, literature on crowdsourced delivery has attracted immense and diverse attention from scholars.

BENEFITS OF CSLMD

Financial benefits

Logistic service providers satisfy the needs of the customers by delivering the right parcel to the right location at the right time for the right price (Li et al., 2019). Therefore, the right price is important ensuring logistic service quality (LSQ) as it positively influence the customer satisfaction, customer loyalty, cost efficiency and sales growth (Ha Ta et al., 2022). The price in crowd sourced LMD is two folded. It could be the price offered to the crowd in exchange of their service which is an expense to the logistic service provider, or the price charged by the customer which is an income to them. Leveraging CSLMD offers advantages in both scenarios: it has the potential to decrease operational expenses for the provider while simultaneously offering customers a cost-effective shipping option, thereby boosting revenue. A case study done by Seghezzi et al (2022) concluded that crowdsourced delivery is more economical than traditional deliveries. Another two studies by Seghezzi et al (2021) and Le (2019) also showed similar results. Therefore, crowdsourcing has the ability of reducing the operational cost. Less driver cost due to the lack of labour specialization and sharing of fixed and operational costs are the key reason for this lower cost (Mangiaracina et al., 2019). Another cost saving is reduction in investment cost in crowdsourcing. Business expansion for express courier companies is costly due to investments on vehicles and hiring drivers. With the introduction of crowdsourcing these costs be eliminated (Johnson and Chaniotakis, 2021, Li et al., 2019). In terms of operations, the cost of vehicle idle time and empty moves also can be avoided with crowdsourcing the LMD (Castillo et al., 2018). Further, termed as asset lightness, lower level of assets owned and managed by a courier company results in lower depreciation, maintenance, and depreciation cost (Gläser et al., 2021, Buldeo Rai et al., 2017). These operational and investment cost savings can be translated into customer benefits such as low prices and greater flexibility which will result in high sales turnover. Using CSLMD therefore has several financial benefits.

Operational Efficiency

CSLMD enables sharing and collaboration of idle or underutilized resources such as vehicles and linehaul space, leading to collective consumption, this improves efficient utilization of resources, skills and time of both the crowd and the courier company (Rechavi and Toch, 2022). Crowdsourcing also contribute towards the route optimization as it matches the driver's route against the destination of the delivery (Rechavi and Toch, 2022, Li et al., 2019). Utilizing crowd-sourced last-mile delivery offers a cost-effective solution for expanding the distribution network into a wider area as they're tapping into a widely spread network of crowd drivers (Carbone et al., 2017). Another study identified that CSLMD is having benefits of higher punctuality rates and higher customer satisfaction (Li et al., 2019). Further, in hybrid operational model using both crowdsourced and dedicated fleet has the benefit of information aggregation (Li et al., 2019) which can be used for process improvements. For example, traffic information, knowledge on short routes and fast routes can be included into process improvements such as route planning which can increase the driver agility (Gläser et al., 2021, Le et al., 2019). Demand fluctuations in the market is an ongoing challenge faced by the express courier industry which can be solved if there is an additional supply of vehicles and drivers stretching the operational abilities of the firm. This is another benefit of crowdsourcing. Studies have shown that crowdsourced fleet can do more timed deliveries than a traditional delivery making it more suitable for more critical package deliveries, managing excess capacity (Castillo et al., 2018) and same day deliveries (Seghezzi et al., 2021).

Sustainability impact of crowdsourced last mile delivery

Globally, the transport sector is responsible for 24% of Carbon Dioxide (CO_2) out of which freight vehicle emissions are 2.4 Gigatons of Carbondioxide ($GtCO_2$) (Johnson and Chaniotakis, 2021). The environmental effects of last mile delivery are not limited to these emissions but also creates noise pollution, road safety issues and traffic congestions (Buldeo Rai et al., 2017) stressing the importance of using green delivery methods. CSLMD is identified as a more sustainable delivery approach compared to traditional delivery methods due to its trip sharing nature (Nieto-Isaza et al., 2022). However, in an event of additional detour, the said sustainability impacts can be diminished (Buldeo Rai et al., 2017, Marcucci et al., 2017, Paloheimo et al., 2016). A different perspective was brough forward when three types of sustainability benefits from CSLMD were identified named Social, economic and environmental sustainability (Buldeo Rai et al., 2017). On this context, CSLMD via public transport are identified to have no direct impact compared to that of owned vehicles on traffic congestions or environmental pollution (Simoni et al., 2020) therefore for traditional delivery to be more sustainable logistic service providers can go for a hybrid or fully CSLMD model.

CHALLENGES OF CSLMD

Service level.

Even though CSLMD can be used the achieve route optimization, this can also be a cause for decreasing road safety and increasing traffic congestion (Moncef and Dupuy, 2021) which can be eliminated by using low emission vehicles such as electric vehicles or bicycles (Punel and Stathopoulos, 2017). In CSLMD, the risk of uncertainty can be high (Castillo et al., 2018). Reliability and service level are essential factors in this industry, making uncertainty a major concern. It leads to inefficiencies and compromises the quality of service, creating negative outcomes for both the courier service provider and customers. However, crowdsourcing could increase the supply chain responsiveness at the expense of reliability (Castillo et al., 2018, Li et al., 2019). In traditional delivery the front-line staff represent the brand image through uniforms and branded vehicles which will be discontinued with crowdsourcing (Castillo et al., 2018) and that can be a disadvantage in long run brand development. In comparison to other logistic services LMD has a higher ability crowdsourcing as it requires minimum skills (Carbone et al., 2017). However, it can be argued that crowd without proper knowledge can be a threat (Gläser et al., 2021).

Security

The security of the packages, the liability of potential damage, theft, breakage in crowd deliveries are unavoidable risks which is also poorly researched (Castillo et al., 2018). The relevant legal aspects about the liability of compensation for a parcel damage by a crowdsource driver or a road safety issue like an accident to the crowdsource driver are still unclear (Gläser et al., 2021). Further, the insurance cost and labour laws of specific countries also need to thoroughly investigate before adopting CSLMD (Gläser et al., 2021, Carbone et al., 2017). One such example is "European agenda for the collaborative economy" which provides legal guidance for policy makers and businesses on managing sharing economies (Buldeo Rai et al., 2017). The heavy dependency on internet, smartphones and crowd platform also imposes a challenge in crowdsourcing in an event of a system malfunction leading to loosing communication and control over crowd drivers (Le et al., 2019). This can lead to other issues such as theft and mishandling of packages. These are compliance risks for an express courier company and security can't be compromised. These risks can be better managed with a proper crowd platform (Li et al., 2019).

Another major challenge is privacy issues, security of sensitive and personal information (Wang et al., 2016, Gläser et al., 2021, Le et al., 2019). Respecting and protecting this information are the responsibility of the logistic service provider. Giving a third party like crowd drivers access to such information can have significant negative consequences unless managed properly. The same principal applies for the crowd drivers which gives logistic service provider the ability to track their real-time location and personal information. Surprisingly, a study shows that crowd drivers are not concerned about privacy issues (Punel et al., 2018).

Future research agenda

Several observations on the future research directions in the discipline of CSLMD were made at the end of this literature review. More research needs to be done focusing on the express courier industry's readiness for supply chain management 4.0 (Jie, 2023) including innovative delivery methods including CSLMD. The business-to-business crowdsourcing capabilities, managing crowdsourced security risks, insurance, and legal aspect of CSLMD are also identified future research areas. Further, more supply chain practitioners need to participate in these studies to make them more industry friendly and practical. The operational and customer service side of using CSLMD, marketing, branding, and human resource aspect of using CSLMD are also identified as future research areas.

CONCLUSION

LMD is one of the key functions performed by express courier companies and successfully managing all aspects of it is important. CSLMD is identified as one the most practical innovative solutions, this was proven by many successful projects such as Amazon Flex. A key observation however is that crowdsourcing has not gained its acceptance among the express courier market. There are challenges in implementing crowdsourcing for an express courier company than a parcel delivery operation. The benefits of using crowdsourcing outreach the challenges. However, to enjoy the maximum benefits of crowdsourced last mile proper execution and controls should be in place. Therefore, this study is aimed at identifying the challenges for an express courier company to adopt CSLMD and proposing solutions to them using the BMI Framework. The efficiency and flexibility it extends along with other benefits such as low cost and fast deliveries can help in managing the current and future trends in the express courier industry.

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An End-To-End GHG Emissions Assessment for Transitioning to a Decarbonized Parcel Supply Chain

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INTRODUCTION

Supply chain activities have a significant environmental impact and associated emissions. Freight transport activities, in particular, pose a challenge for enhancing supply chain sustainability (Eriksson, Dubois and Hulthén, 2022). According to the Paris Agreement, by 2050, transportation will be decarbonized by transitioning to a more sustainable and diversified variety of modes and vehicle technologies for both passenger and freight movement, including mail and parcel shipment, which is increasing in the e-commerce era (Mishra, Singh and Govindan, 2023). To limit global warming and meet the Paris Agreement, the greenhouse gas (GHG) emissions framework is the tool with which an organization communicates its GHG emission results in order to recognize the organization's environmental impact with the effort of reduction as sustainability performance. The Global Logistics Emissions Council (GLEC) framework intends to include all freight transit and hub operations along the supply chain (end-to-end). An organization's emission footprint from its operations is the sum of emissions of all transport chains (Smart Freight Centre, 2023).

The purpose of the study is to estimate GHG emissions in the parcel transportation chain using a Thai postal service provider, to analyze the scenario of an end-to-end transportation chain with different modes, and to provide strategies to improve sustainable performance.

LITERATURE REVIEW

The Sustainable Supply Chain is a concept that incorporates economic, ecological, and societal metrics into supply chain operations. Organizations have to examine not only their direct operations but also supply chain operations, considering all three sustainability considerations (Chanchaichujit, Pham and Tan*, 2019; Mangla et al.*, 2020). In recent years, numerous companies have implemented sustainable supply chain strategies to mitigate the negative impacts of their supply networks on the environment and society. The goal is to reduce adverse environmental consequences. Embracing sustainable business practices is increasingly vital for both expanding businesses and addressing worldwide challenges (Khan, Tabish and Zhang, 2023). Furthermore, many countries and geographic regions employ standardized environmental frameworks to examine and reduce their environmental footprints, which include GHG emissions. The proposed solutions focus on internal constraints within sustainable supply chain management, highlighting the disciplines required for decarbonizing the supply chain (Tsai *et al.*, 2021). In the green logistics supply chain, decarbonizing logistics operations by determining an appropriate mode of transportation, and enhancing the efficiency of operations throughout the transportation network has become a significant issue (Chanchaichujit, Saavedra-Rosas and Kaur, 2017). It leads to strategic decisions on many transportation issues, including switching to low-carbon modes with the use of greener vehicles and increasing the efficiency of energy use and optimizing the vehicle routes, all of which will contribute to the development of a green logistics supply chain (Trivellas, Malindretos and Reklitis, 2020). Moreover, warehouses or transfer hubs are seen as pivotal elements of the logistics supply chain. Strategic decisions must be made regarding several associated matters, including determining optimal numbers and locations. Furthermore, employing diverse methods, such as centralizing freight collection and distribution, is also essential to enhance operational efficiency to reduce costs and carbon emissions (Zhang *et al.*, 2021).

METHODOLOGY

GHG Emission Calculation Framework

The GLEC Framework v3.0 intends to help enterprises understand the GHG logistics emissions that occur from supplier to end user. This Guidance builds on a foundation of existing standards and guidance to assist companies in quantifying and reducing emissions from logistics operations. The GHG Protocol recognizes the GLEC Framework, which is aligned with ISO 14083. Scope 1 of this protocol includes direct emissions from assets owned or controlled by the reporting company. Scope 2 includes indirect emissions from the production and distribution of electricity, heat, and steam purchased by the reporting company. Scope 3 encompasses indirect emissions from the reporting company's supply chain, such as transportation emissions and product consumption. The GLEC Framework v3, which is constantly evolving, divides total GHG emissions into emissions related to energy use for transportation or hub activities and emissions (carbon dioxide equivalent: CO2e) related to the availability of this energy, as represented by model [1].

Emissions [kgCO2e] = fuel consumed [L] × fuel emission factor [kgCO2e/L] [1]

Fuel consumption is measured in liters, however alternative units of measurement are prevalent (e.g., kwh or kg).

Based on this framework, to compute the transport activity of a transport chain element (TCE), a company must first determine the freight mass and distance being transported from consignor to consignee. And to establish the emission intensity for a specific TCE, initially identify which transport operation categories (TOC) and hub operation categories (HOC) are associated with this TCE. A TOC is a group of transport operations (such as the mode of transportation), whereas a HOC is a group of hub operations (hubs or terminals with transshipment or warehousing). To allocate emissions to logistics activities and compute the emission intensity of TOC or HOC, the activities must be calculated using models [2] and [3] (where n is the number of TCE considered inside the TOC or HOC):

Transport activity[tkm] = $\sum_1^n$ transported mass $[t]_n$ x transport distance $[km]_n$ [2]

Hub activity[t] = $\sum_1^n$ transported mass $[t]_n$ [3]

The GHG emission intensity measures the relationship between GHG emissions and the transport or hub operations that generated them. It can be expressed as CO2e per tonne-kilometer for transportation and CO2e per tonne throughput for freight hubs. The emission intensity can therefore be estimated by dividing total emissions by logistics activity, as demonstrated in models [4] and [5].

Emission intensity of TOC [kgCO2e/tkm] = $\sum_1^n$ [total Transport Emissions [kgCO2e]/ total transport activity [tkm]] [4]

Emission intensity of HOC [kgCO2e/t] = $\sum_1^n$ [total hub emissions [kgCO2e]/ total hub activity [t]] [5]

In practice, obtaining primary data can be problematic; thus, alternate calculating methods based on modeled or default data (emission intensity) can be utilized that the empty distance and loading factor settings for transportation are automatically included in the calculations. The emissions for the TCE were then calculated using models [6] and [7].

For transport operations, Emissions per TCE [kgCO2e] for transport operations = TOC emission intensity [kgCO2e/tkm] × mass of consignment[t] ×TCE distance [km] [6]

For hub operations,

Emissions per TCE [kgCO2e] for hub operations = HOC emission intensity [kgCO2e/t] × mass of consignment[t] [7]

The overall GHG emissions of a transport chain are estimated by adding the GHG emissions from each of its TCEs. So, end-to-end supply chain emissions are estimated by aggregating each TCE's unique emissions, as shown in [8].

Emissions of transport chain (end-to-end) [kgCO2e] = $\sum_1^n$ emissions of TCE_n [8]

End-to-end Parcel Supply Chain

Figure 1 displays Thailand Post's parcel supply network, which is employed in this study, while Table 1 offers information on the specified route in this supply chain.

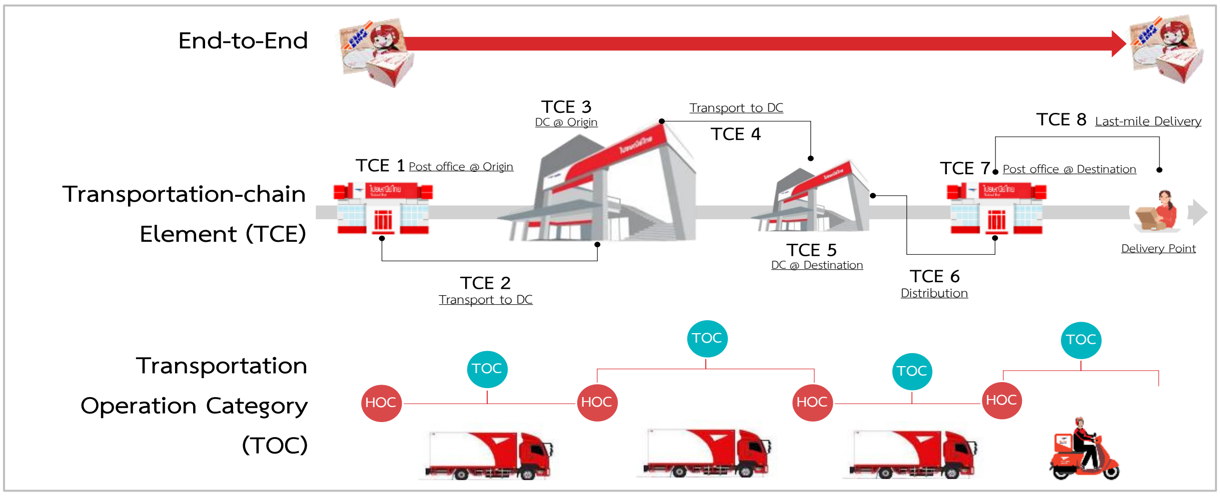

Figure 1: Parcel supply chain of Thailand post

Table 1: The Details of parcel supply chain of Thailand post

TCE	TOC/HOC and Activity	Source of Emissions
TCE 1: The post office in the origin area	HOC: Parcel collection (175 tons)	-Scope 1: Operational fuel related emissions from forklift operations utilizing diesel fuel and -Scope 2: Electricity related emissions of site equipment and facility
TCE 2: Transportation to DC	TOC: Road transportation (2 kilometers)	-Scope 3: Related energy provision emissions (outsourced transportation) employing rigid trucks 3.5–7.5 ton GVW of diesel fuel
TCE 3: DC in the origin area	HOC: Parcel transshipment (11,555 tons)	Similar to TCE 1
TCE 4: Transportation to DC	TOC: Road transportation (962 kilometers)	-Scope 3: Related energy provision emissions (outsourced transportation) employing rigid trucks 7.5–12 ton GVW of diesel fuel
TCE 5: DC in the destination area	HOC: Parcel transshipment (1,267 tons)	Similar to TCE 1
TCE 6: Distribution to the post office in the destination area	TOC: Road transportation (106 kilometers)	Similar to TCE 2
TCE 7: The post office in the destination area	HOC: Parcel sorting (10 tons)	Similar to TCE 1
TCE 8: Last-mile delivery	TOC: Road transportation (30 items)	-Scope 1: Operational fuel-related emissions (last-mile delivery operation) utilizing a motorcycle with gasoline fuel

DC: Distribution center, GVW: Gross vehicle weight

RESULTS

Calculation Result of Baseline

For the calculation results, beginning with a single mode of road transportation from the origin to the destination including last-mile delivery, this is a typical operational process for the postal service provider case study. The TOC's GHG emissions are determined by several parameters, including the distance (which is related to fuel consumption), the type of vehicle, and the overall weight with loading rate. Data on the various characteristics were obtained during peak operation in January 2023. The parameters and associated models are then utilized to calculate a sample of a light weight shipment weighing 5 kg along the specified route. Table 2 displays the calculated results.

Table 2: The computed results for light weight parcel 5 kg

TCE	1	2	3	4	5	6	7	8	End–to-end
CO2e (gCO2eq)	176	3	142	*1,010	140	172	*675	35	2,353

* Emissions hotspot along the transport chain

According to Table 2, the CO2e emissions for the baseline of road transportation for the specified route are 2,353 gCO2eq. TCE 4 is the emissions hot spot of TOC, with the greatest emission of 1,010 gCO2eq due to the long-haul transportation distance, whereas TCE 7 is the highest HOC emissions due to its low transport mass.

Modal Shift Analysis

For the analysis of modal shift, from road to air, using passenger airline cargo services for faster shipment (for TCE 4, long-haul transportation), GHG emissions increase significantly, reaching 6,149 gCO2eq (2.6 times those of a single mode of road). Furthermore, from road to rail, it was revealed that replacing road routes with rail routes (for TCE 4) will significantly reduce overall GHG emissions from 2,353 to 1,503 gCO2eq (-36%).

This work also investigates the transition from road to water mode that incorporate coastal or short-sea waterways, such as island destinations. In comparison to road transportation over the same distance, inland waterway transportation using a Ro-Pax ferry (a mix of roll-on roll-off freight and passengers) dramatically reduces GHG emissions of selected TOC by -59%.

Energy Transform and Energy-efficient Analysis

The scenario of electric vehicle (EV) transformation is also established for all TOC, the total emission reduced from 2,353 to 1,890 gCO2eq (by -20%).

Furthermore, GHG emissions from the HOC fluctuate based on the primary elements, which are the rate of energy consumption (connected to working hours) and the total weight of items passing through the hub. The results demonstrate that high GHG emissions occurred at the service station with low volume throughput.

The hub consolidation scenario is established for low volume post offices, assuming a 50% volume increase. The overall emission decreased from 2,353 to 2,015 gCO2eq (by -14%). In addition, the hub energy efficiency scenario is constructed for all hubs, assuming a 10% decrease in electrical energy, the total emission fell from 2,353 to 2,270 gCO2eq (by -4%).

In summary, Figure 2 depicts a comparison of the results to any scenario in which the baseline for a single mode of road transportation is set to 100%.

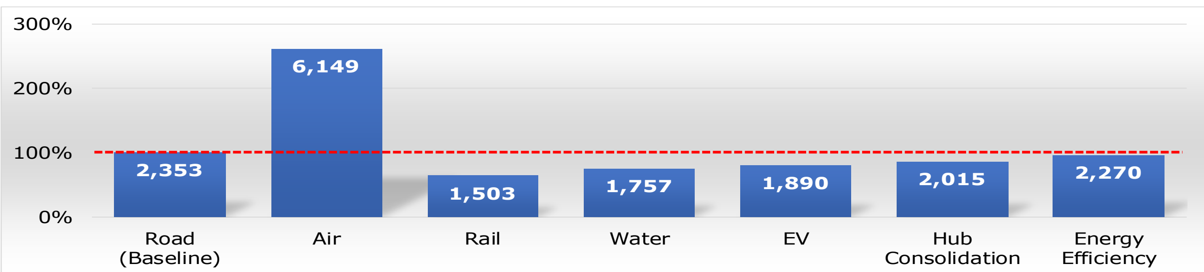

Figure 2: The comparison of results

DISCUSSION

Emission accounting and reporting is an output of the GLEC Framework tool to assist enterprises in making the greatest use of themselves, optimizing organizational activities, and all supply chain participants in meeting climate targets. In terms of case organization, up-to-date strategies proposed based on GHG emission results can enhance strategic decision-making value by providing managerial insights, as shown below.

1) Promoting intermodal transportation: Particularly, two or more modes transit should be an important component of the transportation chain along potential routes (Eriksson *et al.*, 2022). As a result, the strategy for transitioning from road to rail in a conceivable route is a key strategy for reducing GHG emissions from the company's logistical activities. Waterways should be created to reduce the overall distance traveled by road. For coastal areas, there is also the possibility of strengthening parcel transporting by sea. To leverage air transport to provide a service advantage that emphasizes speed, the service price should incorporate GHG compensation costs, as economic considerations should not be limited to one dimension. To minimize empty backhauls, which are a significant source of GHG emissions, network architecture must be carefully examined when connecting roadways to rail, air, or water.

2) Energy strategy with low or near-zero GHG emissions: Energy solution is the primary approach for reducing GHG emissions in logistics operations. Many sources of energy offer minimal or near-zero GHG emissions (Zing *et al.*, 2021). Switching to other energy types, such as electric should be considered, especially in transportation activities where emission volumes correspond to fossil fuel consumption rates. Using electrical energy instead of fossil fuels is a popular alternative. It is widely utilized in the transportation sector and is expected to grow in the future. Furthermore, this strategy can minimize air pollution while increasing potential to establish new work systems that benefit society (Trivellas *et al.*, 2020). However, in the case of practical EV applications, the average reduction in TOC GHG emissions will be close to nil, but this will have an impact on HOCs designated as charging points for vehicles with enhanced electrification. In this regard, identifying the suitable charging point necessitates more in-depth research into the cost of installation at each post station in order to get a return on investment in a reasonable amount of time. And, in order to operate or use an EV efficiently, there must be a balance between the vehicle being loaded and charged.

3) Supply network redesign: Hubs should be effectively managed, for example, by closing or consolidating low-throughput service stations (Zhang *et al.*, 2021). The conversion of distribution stations to smaller scales, such as last-mile distribution depots, should be investigated. However, additional criteria, such as spatial suitability or the distance between each post office to be combined, may need to be addressed while implementing this approach. Including the projected additional workload from the merger as well as the main post's maximum capacity. Furthermore, marketing factors must be considered, as well as the convenience of access for customers of the service. For example, areas where the post office has been cancelled may necessitate an adjustment of the service format to a mobile postal unit that still receives parcels before collecting and sorting them at the main post office, so that customers in the area are not impacted.

4) Energy-efficient: The method of boosting energy efficiency by reducing the consumption of electricity and fuels has the potential to reduce GHG emissions (Trivellas *et al.*, 2020). In terms of TOC, the reduction in GHG emissions is attributable to the implementation of the shortest distance principle for parcel distribution. However, this is because identifying the shortest distance in each delivery cycle is challenging due to the varying positions of each cycle. Every cycle delivery requires a distance calculation; the real application may necessitate the use of information technology for analysis. For HOC, the use of alternative energy sources at hubs, such as solar energy, should be prioritized. Installing solar panels to convert solar energy into electrical energy will help to minimize power usage from producers (Scope 2). In practice, it may be important to consider the suitability of the installation point when determining how many can be installed. If any area has a high potential, it may be able to cut its electricity usage rate from the electricity, which must be studied further.

CONCLUSIONS

This study establishes key principles for disclosing logistics activities emissions using the GLEC Framework v3.0. As a result, the strategies are founded on the supply chain notion of end-to-end perspective. The framework reflects reality and organizational use cases to ensure that accounting and logistics emission reduction solutions may be integrated into daily procedures. It also develops the rationale for aspiration levels, encouraging businesses to gradually enhance data granularity, quality, and reliability. However, to complete the framework notion, the assurance and verification process should be carried out to determine the level of confidence in the assurance statement and to identify the gap between utilizing default or modeled data and the highest degree of confidence using primary data. That is also used to construct the primary data collection platform to increase the quality of the report.

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Investigation of supply chain transparency practices of buyer firms from modern slavery reporting

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1.0 INTRODUCTION

The term "modern slavery" in supply chains denotes the exploitation of workers, regardless of their role in the production process (Crane, 2013). This is an alarming issue, and the United Nations Sustainable Development Goals (UNSDG), particularly target 8.7 has highlighted the urgent need to eradicate slavery by 2030 (Burritt & Christ, 2023; Meehan & Pinnington, 2021). Due to its complexity and the involvement of multiple stakeholders, modern slavery is recognised as a wicked problem (Crane et al., 2019), and while quantification remains problematic, the latest figures estimate that 50 million people are trapped in modern slavery worldwide (GSI, 2023). Recognising transparency as a critical component in the fight against this egregious violation of human rights, OECD countries have enacted legislative acts, requiring firms to disclose their practices to address modern slavery issues. These include the UK Modern Slavery Act 2015, the Australian Modern Slavery Act 2018, and the recent enacted Canadian Modern Slavery Act 2023 (Friedman, 2024; Geng et al., 2022).

The lack of visibility in upstream supply chains has spurred the rise of modern slavery scandals (Islam & Van Staden, 2022). Recent events include forced labour exploitation in Tesla's battery supply chains in Xinjiang (2024), the fatalities of workers in the fire in Peru's La Esperanza gold mine (2023), malpractices within the medical gloves factories in Malaysia (2021) and the devastating factory collapse in Rana Plaza (2013) (Halper, 2024; Sinclair et al., 2022). The consequences of these scandals underscore the critical importance of transparency, as highlighted in recent KPMG (2024) report on the *Futures of Procurement*. Transparency has a profound impact not only on firm's social impact, but their financial success and reputations (Morgan et al., 2023). Recognising transparency as both a strategic necessity and moral imperative, firms must embed social responsibilities in their supply chain practices to safeguard their viability and social integrity.

The current problem is that little is known about the information firms disclose in relation to supply chain transparency in modern slavery reporting. Academic studies, to date, have focused on legal compliance and the motivations behind firms' disclosures (Han et al., 2022). Most firms are in early majority stage, where they monitor only direct suppliers (Bateman & Bonanni, 2019). Even amidst increasing stakeholder pressures, 67% of procurement leaders surveyed globally acknowledged deficiencies in their risk reporting, and do not rate it as "highly mature". Moreover, 52% of firms in Australia had failed to track modern slavery risks in upstream supply chains, and only 27% of them have implemented effective practices (Sinclair et al., 2022). Evidently, firms remain unclear about how to approach for reporting information for transparency, highlighting the need for comprehensive research.

The aim of this research is to explore how buyer firms respond to supply chain transparency through modern slavery reporting. Examining the modern slavery statement from Australian healthcare sector, we fulfill the research aim through the following questions:

RQ1. What do buyers monitor for modern slavery in upstream supply chains?

RQ2. What supply chain practices are buyers adopting to improve supply chain transparency?

RQ3. What supply chain transparency information do they disclose to the stakeholders?

2.0 RESEARCH CONTEXT

The unsettling truth of modern slavery lurks within healthcare PPE supply chains, spanning across Malaysia, China, India, Pakistan and Thailand (Barnett et al., 2021). Within medical gloves factories, forced labour practices were documented, with workers enduring egregious conditions, ranging from relentless work hours to the confiscation of identity papers (Hughes et al., 2023). During the COVID-19 pandemic, many hospitals have expedited their procurement process, bypassing supply chain due diligence, which exacerbated the conditions of workers. In the post-pandemic era, PPE's necessity persists due to projected global population growth by 2030 and the anticipated 60% rise in Australia's elderly population (AIHW, 2023). Despite calls for transparency about labour conditions across various industries, the healthcare sector exhibits notable deficiencies. Research among Australian Securities Exchange (ASX) firms indicates poor transparency disclosures in healthcare (Walden, 2020), with over 50% of the firms receiving the lowest transparency score in identifying slavery issues in their PPE supply chains (Sinclair et al., 2022). This irony is stark, given that the sector purports to value human welfare, and saving lives should not involve exploiting vulnerable individuals. These findings should serve as a wake-up call, as while modern slavery issues are not unique to Australia, they cannot be addressed until supply chain transparency is enhanced.

3.0 LITERATURE REVIEW

The complexities of modern slavery, coupled with its prevalence in upstream supply chains pose a challenge to supply chain transparency (Crane, 2013). Initially rooted in notions of ownership-like control, definitions of modern slavery now encompass coercion and deception (Geng et al., 2022). In the supply chain context, Crane (2013) defines modern slavery as the exploitation of workers, irrespective of their role in the production. While modern slavery is dynamic, it is often prevalent in regions with weak labour regimes, high poverty rates and corruption indices (Crane, 2013), particularly in labour-intensive and upstream raw material supply sectors such as fishing, mining, electronics, cotton, and textiles (Han et al., 2022). These sectors, characterised by low profit margins, rely on low-cost labour. This is compounded by unethical practices, where firms may engage in mock compliance by concealing workers, which hinders the effectiveness of social audits in assessing labour conditions (Pinnington et al., 2023). This highlights the ongoing challenges of achieving transparency when overseeing upstream suppliers.

Supply chain transparency (SCT) has since received growing attention in addressing modern slavery risks (Mollenkopf et al., 2022; Morgan et al., 2023). SCT involves reporting and communicating with stakeholders to provide traceability of the product's history and visibility about supply chain activities (Carter & Easton, 2011; Carter & Rogers, 2008). Specifically, Morgan et al. (2023) define SCT as comprising two key components: visibility and traceability. Visibility signals information to supply chain stakeholders, while traceability pertains to the operational aspects that support the ability of supply chain monitoring, often influenced by technology (Morgan et al., 2023). In other words, traceability allows tracking products across multiple tiers of suppliers, and visibility ensures effective communication with stakeholders. In this way, both constructs are distinct yet complementary, with investing in traceability should enhance visibility and vice versa. As such, firms need to embrace both traceability and visibility to be transparent, and neither can be ignored entirely. Yet, many firms struggle to establish traceability. Research indicates that nearly 60% of firms do not maintain accurate records of their suppliers, providers, and labour conditions (Egels-Zandén et al., 2015; Gardner et al., 2019; Wowak et al., 2016). This leads to information asymmetry and a lack of information flow between supply chain actors, highlighting the need for further research into information disclosure.

With the advent of transparency legislation, the research on modern slavery disclosure emerges. These studies employ content analysis to examine the quality of reporting and the efficacy of sustainability initiatives. Stevenson and Cole (2018) uncovered the heterogeneous practices of buying firms. Building on this insight, recent investigation by Islam and Van Staden (2022) into conflict mineral disclosures highlights the influence of NGOs in promoting transparent disclosure. Meanwhile, Ras and Gregoriou (2019) expose recurring metaphors of UK retailers in their reports. These studies are conducted in the UK context due to the early implementation of the UK Modern Slavery Act 2015, however it raises concerns regarding the generalisability of the findings, prompting research in other geographical areas. Recent studies in Australia have examined various industries, including textiles industry. In their findings**,** Rao et al. (2022) investigated the influences of disclosures among firms under less stringent legislative guidelines. Meanwhile, Richards (2022) examined audit and grievance mechanisms and the impact of COVID-19 in the fashion sector. These studies have predominantly focused on understanding firms' motivations for disclosure practices and themes of legal compliance (Gardner et al., 2019; Han et al., 2022), there remains a gap in information disclosures when investigating the SCT aspect of modern slavery reporting.

Institutional theory, legitimacy theory and stakeholder theory remain prominent in contemporary modern slavery disclosures research. Institutional theory is used to explain the homogenisation of firms practices due to normative, coercive, and mimetic pressures (Rao et al., 2022), while legitimacy theory has been employed to explain how firms disclose voluntarily to affirm social contract (Schaper & Pollach, 2021). Meanwhile, stakeholder theory has been advocated in future disclosure study (Han et al., 2022). It encompasses descriptive, instrumental, and normative aspects (Siems et al., 2023). The normative stakeholder perspective argues that there is an ethical obligation for firms consider all legitimate stakeholders interests and to be responsive in disclosing to all stakeholders (Hörisch et al., 2014). These include internal (employees), downstream (customers), societal (NGOs, governments), market (competitors), and upstream suppliers. They can act as drivers to support firms to address modern slavery risks and ensure the adoption of SCT practices (Siems et al., 2023). Thus, it highlights an opportunity to explore firms' disclosures from stakeholders' perspective.

4.0 RESEARCH DESIGN

The study adopts an inductive content analysis (see Figure 1), examining themes related to supply chain transparency in the context of modern slavery reporting in Australia.

Initial read through statements	Label specific quotes	Label quotes to create categories	Merge overlap codes to reduce redundancy	Create a model of categories
Many pages of text	Many quotes	30-40 categories	15-20 categories	3-8 categories

Figure 12: Coding process

4.1 Data Collection

This study analyses the secondary data from healthcare firms' modern slavery reports under the Australian Modern Slavery Act 2018, collected from the Modern Slavery Registry. This approach is suitable since obtaining primary data concerning illegal activities is challenging (Geng et al., 2022). As of 2023, 78 healthcare firms submitted modern slavery reports between 2022 to 2023 forming the final sample size. The sample is comprised of a complex mix of entities including 40 public and 38 private firms. These include hospitals and sub-industries such as medical care, residential care, specialist medical and allied health services. One limitation is that some firms, particularly, six of those firms do not release their modern slavery reports on an annual basis. Hence their reports of 2021 to 2022 were included for analysis.

4.2 Data Coding and Analysis

While various techniques exist for inductive content analysis, this study follow a systematic step suggested by Elo and Kyngäs (2008) and Thomas (2003):

(i) Preparation and reading of text: First, the researcher thoroughly reviewed all 78 reports to grasp an understanding, then imported them in PDF format onto the Nvivo12 software. Pseudonyms (O1, O2) were also used to maintain the anonymity of firms.

(ii) Open coding, create and group categories: The researcher then started open coding process, which results in 350 initial codes. Similar codes were merged and grouped under higher order categories, considering their relevance to the literature.

(iii) Continuing revision and abstraction: Within each category, the researcher searched and grouped the subthemes. This process continues as far as is reasonable.

Validation of the coding involved two other researchers reading a sample of 20 statements, resolving any differences of opinion through discussion, which led to the identification of **12** sub-themes (2nd order codes) listing how many reports represented in the codes and **4** key themes (theoretical categories), as shown in Figure 2.

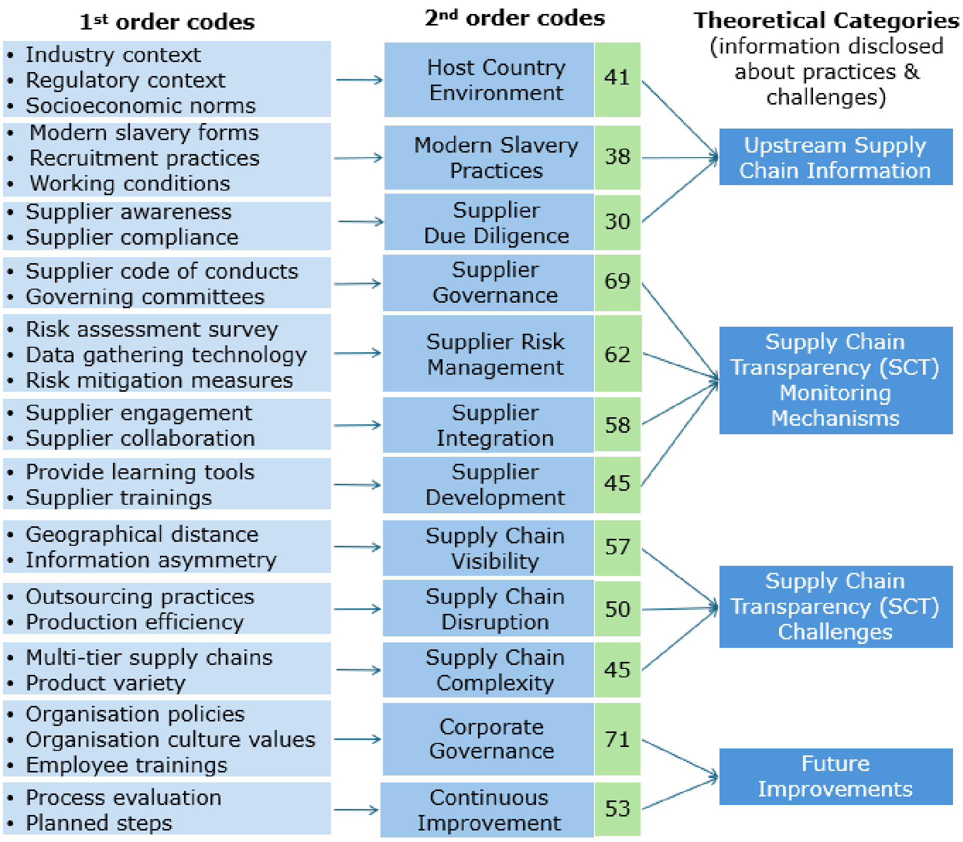

Figure 13: Codes, categories, and frequency of themes

5.0 FINDINGS AND DISCUSSION

This section discusses the supply chain transparency themes that healthcare firms have disclosed in their reports followed by a developmental of conceptual framework.

5.1 Upstream Supply Chain Information

In examining their upstream supply chains, healthcare buyer firms shed light on three key areas: host country environment, modern slavery practices and supplier due diligence.

O37 pointed the countries of their suppliers and stated: "these countries have publicised records of modern slavery, where the rule of law is low and low-cost labour is the norm". Moreover, firms have unearthed several forms of modern slavery, deceptive recruitment practices and exploitative working conditions. O15 added that: "workers were subjected to having their identity papers taken, charged excessive recruitment fees, long working hours, exposure to dangerous substances, poor food and accommodation". Revelations from healthcare firms indicate the lack of human rights due diligence and awareness among upstream suppliers. As O2 stated: "A number of our medical suppliers are smaller entities that do not have operational modern slavery due diligence or risk identification frameworks". This lack of awareness and labour oversight has the potential to lead to circumstances where forced labour practices thrive (Han et al., 2022).

In essence, most healthcare firms are reporting basic and generic information on visibility of their upstream supply chains. This may be due to fears of disclosing more information would jeopardise their competitive edge and expose them to stakeholders' criticism (Morgan et al., 2023). Upstream stakeholders are a fundamental and vulnerable part of the supply chains, as in, they contribute to the operations and production processes of buyer firms, yet they often face injustices which makes them prone to exploitation (Crane, 2013; Van Buren & Schrempf-Stirling, 2023). Hence, it is fundamental for healthcare firms to also engage with upstream stakeholders and respond to their legitimate interests, such as those suppliers and workers the in upstream supply chains (Burritt & Christ, 2023).

5.2 Supply Chain Transparency (SCT) Monitoring Mechanisms

Supplier governance stands out as a key focus to manage SCT. As O40 highlighted, "Our governance structure underpins our operations, with Supplier Code of Conduct and Modern Slavery Standard to support a transparent framework for all stakeholders". This mechanism ensures supplier compliance to buyer's inter-organisational expectations. Supplier risk management is another commonly adopted mechanism, including risk assessment (i.e. slavery questionnaires) and mitigation measures (i.e. whistleblowing channels). In cases of non-compliance, most firms have adopted supplier integration, through maintaining open dialogue with suppliers, while some have adopted supplier development approach. For instance, O26 added it "educates suppliers and assists suppliers with identifying risks of modern slavery". This allows them to guide their suppliers and work collaboratively to better mitigate modern slavery risks (Christ & Burritt, 2023).

In examining SCT disclosures, the study highlighted several monitoring mechanisms adopted by healthcare entities: supplier governance, supplier risk management, supplier integration and supplier development. Most healthcare firms have exhibited proficiency in supplier governance, yet this often involves allocating limited resources to their suppliers (Venkatesh et al., 2020). This is evident as only a minority have progressed in supplier development. Such mechanism is crucial for enhancing suppliers' modern slavery risk mitigation capabilities (Burritt & Christ, 2023), and encouraging information sharing to enhance the visibility of supply chains (Siems et al., 2023; Stevenson & Cole, 2018). Some firms also partnered with third-party providers to utilise data-sharing technologies for monitoring suppliers, which is essential for establishing traceability of their supply chain activities (Morgan et al., 2023). However, few firms have incorporated such mechanisms, possibly due to the non-legislative requirement of the Australian Modern Slavery Act 2018.

5.3 Supply Chain Transparency (SCT) Monitoring Challenges

Beyond reporting on SCT mechanisms, firms acknowledged the SCT challenges in monitoring invisible aspects of supply chains. O66 added: "There are multi-tiered complex global supply chains, and it is difficult to gain visibility several layers down into the overseas sub-contractors". It is difficult to monitor upstream supply chains due to the fragmentation and complexity of multi-tiered supply chains (Grimm et al., 2016). In times of supply chain disruptions (i.e. COVID-19), healthcare firms have made quick decisions to keep up with unprecedented demands of PPE (Hughes et al., 2023). As O34 stated: "we were required to source outside of regular suppliers, and due to the urgency, we were unable to undertake our normal investigation for modern slavery risks”. Firms often compromise the social sustainability of supply chains, particularly in the supplier preselection process and supplier training on modern slavery policies.

This study has identified several SCT challenges faced by healthcare firms in monitoring slavery risks such as supply chain visibility, supply chain complexity and supply chain disruption. Due to the limited visibility over lower tiers of supply chains, it appears that most healthcare firms faced challenges in identifying slavery risks beyond Tier 1 suppliers, neglecting oversight to Tier 2 and beyond. In reality, modern slavery extends far beyond Tier 1 and encompass a myriad of stakeholders including third-party recruitment agencies and sub-contracting arrangements (Friedman, 2024). The hidden nature of modern slavery further creates barriers for healthcare firms in identifying their stakeholders, suppliers and crucially victims in upstream supply chains (Mollenkopf et al., 2022).

5.4 Future Improvements: Organisation Policy and Process

Finally, healthcare firms have demonstrated strong corporate governance, including establishing organisational policies and values, and employee development. As O1 noted: “We establish a risk identification and management culture to increase capability across the business”. These organisational values help healthcare firms to develop their internal capability through employee trainings. For instance, O49 stated: “Current employees go through regular trainings to reinforce practices to identify modern slavery risks”. It is vital to establish the right corporate culture and actively curtail the harms of modern slavery (Crane et al., 2019). So that firms can train employees to ensure they understand ethical policies and are aware of modern slavery (Matook et al., 2009).

While one of the Australian Modern Slavery Act 2018 reporting requirements is to evaluate actions towards modern slavery risks, most firms are still in the initial stages of evaluating the effectiveness of their mechanisms. However, they have recognised the need for continuous improvement, as O44 added: “Our review of our actions to address modern slavery risks will be an ongoing process that we are committed to continue to build upon”. While this reassures stakeholders, Meehan and Pinnington (2021) argues it may become ‘defensive reassurance’, where consumers may seek comfort by this disclosure. Consequently, it reduces buyers’ intention to actively engage with suppliers and workers in fostering traceability within supply chains and mitigating modern slavery risks.

5.5 Conceptual Framework of SCT Information Disclosure

Effective SCT requires both visibility (ensuring information is communicated clearly to stakeholders), and traceability (allowing for tracking of supply chain activities). Based on the findings, we present a conceptual framework outlining four SCT themes that firms convey to their stakeholders, as depicted in in Figure 3. With the various information disclosed on the visibility of upstream supply chains, we divide them into three categories: host country environment, modern slavery practices and supplier due diligence. Their interaction often fosters the emergence of modern slavery. In the right segment of the framework, we summarise the adopted SCT mechanisms, challenges, and future improvements disclosed to the stakeholders. To monitor modern slavery risks in upstream supply chains, healthcare firms have encountered various SCT challenges and discussed future improvements through corporate governance and continuous improvement.

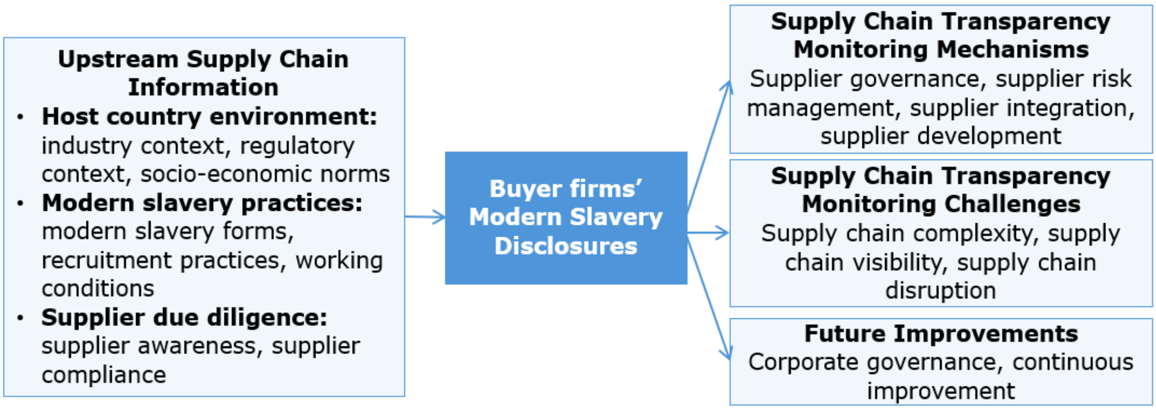

Figure 14: SCT Information Disclosure through Modern Slavery Reporting

One noticeable aspect in the reporting practices across the disclosures is the lack of supply chain traceability, that is, the information of their supply chain activities. This is essential for SCT, however only few firms have disclosed traceability aspects with the use of data-sharing technologies. This may be due to the non-requirement of the Australian Modern Slavery Act 2018.

6.0 CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

Addressing the hidden nature of modern slavery necessitates a continuous commitment to enhancing SCT through visibility and traceability (Crane et al., 2019). Despite the widespread adoption of SCT monitoring mechanisms, which typically involve supplier governance based on established codes of conduct, such mechanism often fails to effectively detect signs of forced labour in upstream supply chains. The feasibility of these SCT mechanisms is called into question owing to the complexity of supply chain and its limited visibility. Implementing SCT mechanisms demands both integration and development of suppliers, and a collaborative approach wherein healthcare firms engage with various stakeholders including governmental bodies, non-governmental organisations, upstream suppliers, and upstream workers to foster traceability of supply chains. Our findings provide valuable insights into healthcare firms' SCT monitoring mechanisms and the nature of information disclosed to stakeholders. We synthesise the findings and its contributions to each research question, respectively:

1. The research identified three critical categories of information disclosed on the visibility of upstream supply chains: host country environment (i.e. lack of labour regulations), modern slavery practices (i.e. deceptive recruitment) and supplier due diligence (i.e. lack of compliance) which are the causes that contribute to modern slavery. Healthcare firms highlighted how the absence of labour rights regulations, coupled with country's reliance on low-cost labour, and insufficient supplier due diligence foster conditions conducive to modern slavery practices. This insight underscores the importance of supply chain transparency. It enables managers to better analyse the factors that contribute to these slavery issues. Only by understanding the roots of slavery can firms effectively identify and combat modern slavery in their supply chains. (RQ1)
2. The study examined four primary facets of monitoring mechanisms to enhance SCT: supplier governance, supplier risk management, supplier integration and supplier development. Many firms displayed robust supplier governance, with some provided modern slavery trainings to their suppliers. A handful of firms have also collaborated with third-party providers, employing data-sharing technologies for supplier monitoring. Healthcare firms can consider collaboration with external stakeholders to harness data-sharing technologies to strengthen traceability of supply chains. As such collaboration can improve the gathering of supplier information and enhance visibility, ultimately aiding in the detection of modern slavery risks. (RQ2)

3. Beyond disclosing the above SCT aspects, the findings revealed that healthcare firms disclosed both challenges and future improvements in SCT monitoring on visibility and traceability. Stemming from the fragmentation and limited visibility of supply chains, exacerbated by COVID-19 disruptions, most healthcare firms only managed to engage with Tier 1 suppliers and therefore disclosed very generic information on their upstream supply chains. While most healthcare firms have demonstrated strong corporate governance, they are in the early phases of evaluating the effectiveness of their SCT monitoring mechanisms. However, firms have underscored their commitment to continuously improve their existing SCT monitoring mechanisms to instil confidence and reassurance to their stakeholders. (RQ3)

Theoretically, this research presents a SCT information disclosure framework, enriching our understanding of current practices under the Australian Modern Slavery Act 2018. It identifies monitoring mechanisms, challenges, and disclosed information about upstream supply chains, highlighting limitations in firms' modern slavery disclosures. Currently, healthcare firms only disclosed information regarding slavery risks up to Tier 1, lacking visibility beyond Tier 2 and beyond. They are also in nascent stages of evaluating their SCT mechanisms against modern slavery risks despite legislative requirements to disclose. Finally, there is a notable lack of traceability monitoring as firms currently only disclose on the visibility of their supply chains. This raises the question of whether requirements on traceability should be incorporated into the Australian Modern Slavery Act 2018. As improving traceability would also enhance visibility across supply chains, thereby strengthening overall SCT.

Practically, the proposed conceptual framework hopes to serve as a guide for firms and policymakers, facilitating their understanding of how they can improve SCT to remediate modern slavery risks within healthcare supply chains. Since not all healthcare firms provide comprehensive disclosure on every dimension of the framework, this SCT framework acts as a roadmap for healthcare firms, outlining the specific areas they could improve and disclose to enhance visibility and traceability within their supply chains. It aims to inspire healthcare firms to reassess their SCT mechanisms and take more proactive measures to combat modern slavery. Through this, this research hopes to contribute, or at least take incremental steps towards, achieving the goal of eradicating forced labour by 2025, as outlined in the United Nations Sustainable Development Goal Target 8.7.

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Industrial Symbiosis as a Synergy-Level Circular Business Model Driving Innovation Through Incentives for the Indonesian Coffee Shop Industry

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BACKGROUND

The business world is currently experiencing an era of digitalization with the development of several disruptive technologies. Such progress, however, entails consequences both positive and negative in character. Competition between commercial enterprises has intensified, while production and consumption-related activities have also proliferated. These activities still entail the burning of fossil fuels, industrial processes, and waste disposal all of which contribute significantly to climate change through greenhouse gas emissions. Despite the progress achieved, this form of volatile growth has resulted in a scarcity of natural resources which, in turn, drives up prices and generates uncertainty (Lacy et al., 2014). Both economic and population growth are considered key drivers of resource demand, culminating in a struggle to balance economic development and resource scarcity, the latter of which can be attributed to the practice of a linear or "take-make-waste" economy within which extracted natural resources are consumed during product manufacture. These resources largely end up as waste disposed of in a manner which emphasises the economic aspect of profitability, rather than environmental considerations. This continuous dependence on natural resources for business growth exposes companies to risks such as reduced revenues, increased costs, and compromised brand value (Lacy et al., 2014).

The circular economy concept emerged as a potential solution to this problem. A closed-loop system, within which nature is regenerated by keeping materials in circulation, employs cyclical processes which basically eschew the use of non-renewable resources in managing environmental problems (Bimantara et al., 2021). The Ellen MacArthur Foundation, a leading proponent of this concept, asserts that the implementation of a circular economy requires four building blocks. These comprise circular economy design, new business models, reverse cycles, and enablers in addition to favorable system conditions such as collaboration, rethinking incentives, providing appropriate international environmental rules, leading by example, driving rapid upscale, and access to financing.

Despite the expected positive impact on economic, environmental, and social factors, however, the Circularity Gap Report (2024) reported a low global circularity practice rate of 8.6%, illustrating the challenges numerous companies face in implementing a circular economy. These may be primarily related to factors including: lack of awareness and understanding of the concept, poor collaboration and coordination, regulatory and other types of barrier, inadequate supportive policies, high implementation costs, limited availability and continuity of recycled materials of the desired quality, complex supply chain practices, weak consumer demand for specific products together with complicated design, production, and disassembling processes. These various factors form the essential background to exploring whether the transition to a circular economy has presented actors with a dilemma, namely, prioritizing profitability or sustainability.

PROBLEM STATEMENT

A highly populated and increasingly industrialized emerging member of G20, Indonesia boasts the largest economy in Southeast Asia while contributing significantly to CO2 emissions, the primary cause of climate change. It is necessary for the country to initiate the transition from a linear to a circular economy due to the increasing importance of maintaining both profitability and sustainability. On a positive note, the Indonesian government, through its Ministry of National Development Planning (BAPPENAS), has been promoting circular economy practice through "The Future is Circular" program (2022) with food and beverage as one of the sectors prioritized to minimize carbon emissions by

2029. These sectors have the potential to drive gross domestic product, job creation, and circularity by gathering the values and support of related stakeholders in doing so. Food waste is considered the largest problem in terms of volume and inefficient management, deficiencies which highlight the importance of economic, environmental, and social sustainability.

This research explores the circularity potential of various forms of coffee shop operating waste as an aspect of the coffee supply chain. Coffee is globally one of the most consumed beverages (Lim et al., 2019), and coffee shops, both stand-alone and chains, involve urban coffee consumption with potentially uncontrolled waste disposal. In Indonesia, coffee shop culture is increasing in popularity among young urbanites, with 2,937 outlets and an estimated annual market valued at Rp.4.8 trillion (Mix Marketing & TOFFIN, 2020). This trend is likely to entail extensive use of takeaway cups and the consequent probability of poor waste disposal practices. Fortunately, the waste, especially spent coffee grounds, has potential use in further economically beneficial processes (Mayson & Williams, 2021). Grounds are easy to collect which is essential since direct disposal of large quantities can produce methane that contributes to climate change (Roychand et al., 2023) in addition to mutagenicity and DNA damage (Fernandes et al., 2017). In contrast, collecting consumer-bound waste such as used cups, presents more difficulty due to the low level of control that can be exercised over coffee shops.

It can be inferred that the reliance on linear economy practices of Indonesian coffee shops, given their limited understanding of the economic value of waste, contributes to potential resource depletion, waste generation, negative environmental impact, and economic inefficiency. The program uses the case of a coffee shop focusing solely on developing eco-friendly paper cups and giving discounts to customers who use tumblers. These initiatives are positive yet have questionable impact due to process-related problems and development costs. Moreover, consumer demand for these particular receptacles is comparatively low due to their being less durable in comparison with plastic cups. In short, they provide no added value for consumers other than positively impacting the environment. Therefore, exploring more potentially fruitful collaborations is necessary to achieve significant impact across all aspects. In fact, circular business models (Lacy et al., 2020, Geissdoerfer et al., 2020) are predominantly collaboration-based, rendering the development of collaborative approaches involving various stakeholders, including consumers, important. One such model is that of industrial symbiosis.

This conceptual paper presents a circular economy implementation framework, in the form of industrial symbiosis, showing the scalability of collaborations. It is expected to help stakeholders in the Indonesian coffee shop industry collectively refrain from linear economy practices in achieving greater sustainability impact through resource use efficiency, waste reduction, cost savings, environmental benefits, and community engagement. The originality lies in its systemic approach to visualizing potential circular collaborations, while addressing potential costs, benefits and impacts by considering business model innovation and incentives to support them in making decisions about their participation. A systemic perspective is essential to cover the causal interactions among all components. Stakeholders will be able to reflect on the costs and benefits of participation through the acknowledgement of possible mechanisms, created business values, and the structure of incentives. While several barriers affecting feasibility exist, the research does not focus on these because it aspires to envision the possibility of implementing an innovative approach to achieving sustainability through potential collaborations which do not limit innovation to any great extent.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Based on the keywords ["Circular" OR "Circular Economy" OR "Circular Supply Chain" OR "Sustainability" AND "Industrial Symbiosis" AND "Business Model"], 52 relevant research papers were collected from the Scopus Database. These mostly discussed industrial symbiosis within strategic development level which is understandable considering low global circularity practice. Papers have been written discussing the transformation implementation and performance measurement aspects of the initiative, largely in relation to European countries. For this reason, this research also discusses the approach on a strategic development level, because only a few studies of the transitioning process within the circular economy and industrial symbiosis exist (Nasiri et al., 2018; Mortensen et al., 2023). This is particularly the case with Indonesia as an emerging country, since it is rarely represented in the literature (Oguntoye & Evans, 2017; Taqi et al., 2022).

Most reviewed articles discuss process optimization with certain exceptions (Fraccascia et al., 2019; Ferreira & Matias, 2021; Kowalski et al. 2021; Mortensen et al., 2023). However, this research aspires to do so by using a systemic and network-based approach that is under-represented. This is supported by the need to study the design and composition of an industrial symbiosis network, its innovations, and performance measurement (Ahmad et al., 2023). A limited number of studies such as that conducted by Baglio et al., (2018), focus on technological enablers of process optimization and this article also highlights the need to study the scalability of business model innovation and its impacts, inferring the burdens and rewards of stakeholder participation. The majority of papers focus on its environmental impact, followed by economic feasibility, and, lastly, social effects. This demonstrates that the balance between economic, environmental, and social impacts in implementing industrial symbiosis is also under-researched (Giunta et al., 2017; Garcia-Muiña et al., 2019; Babkin et al., 2023).

Regarding business model innovation, relatively few studies have focused on business models for industrial symbiosis at a systemic level (Fraccascia et al., 2019) and most do not address their value components. One paper investigates the types of business models to overcome barriers to industrial symbiosis in emerging countries (Zolfani et al., 2023), but the number of similar papers is relatively low. Despite their importance, only few studies on incentives to drive industrial symbiosis have been undertaken (Henriques et al. 2021, 2022), including ones focusing on the role of their structure and values in stimulating participation together with others concerned with business models (Chen, 2020; Pavan et al., 2021). Methodologically, most studies have constructed conceptual models and simulations using either qualitative or quantitative theories. Meanwhile, our conceptual research incorporates a literature review, interviews with coffee shop owners, and case studies in developing a model.

Industrial symbiosis is a sub-field of industrial ecology that describes a dynamic process where separate businesses cooperate to achieve competitive advantage by exchanging materials, energy, water, and by-products, as well as services and infrastructure (Baldassarre et al. 2019). It encourages synergies both internal and between companies with geographical proximity where surpluses from one industry or process becomes the substitute for raw materials for others, thereby prolonging the productive use of resources (Azevedo et al., 2021). Industrial ecology itself represents an ideal state which closely resembles nature, with most total internal cycling of materials (Bocken et al., 2015). This symbiosis is more suitable for manufacturers. Nevertheless, several papers emphasize its flexibility either as more integrative circular solutions (Eikelenboom et al., 2021) providing mutual benefits through informational and operational symbiosis (King, et al., 2023), or involving companies lacking geographical proximity (Chertow, 2000; Borbon-Galvez et al., 2021). This condition underpins both the possibility and importance of considering its application to coffee shops, particularly coffee shop chains with their network outlets. While centered on coffee shops, it covers the supply chain level due to the importance of collaborative exploration among coffee shops, businesses which consume resources, suppliers, and waste-processing companies. Consumers act as the source of demand, government agencies as regulators and possible initiators, with industry associations, NGOs, and academic institutions supporting optimization. The existence of self-organized, third-party facilitated, and government-planned initiatives must also be taken into account (Chertow, 2007).

Industrial symbiosis is viewed as a business model which closes the resources loop (Bocken et al., 2015) whose role becomes apparent when waste management is vital and the waste itself has great potential for use by other industries. A classification of circular business models including circular inputs, sharing platforms, product as a service, product use/life extension, and resource recovery (Lacy et al., 2020) that shows collaborative tendencies. Lacy et al. (2014) categorise it as an 'only resource recovery' model, but it is arguably more suited when combined with other models, e.g. circular inputs, as the use of recycled waste materials is its core concept. It can also involve other models depending on the form of collaboration. Alternative classification (Geissdoerfer et al., 2020) may also be used, especially the type related to recycling, with collaboration possibilities involving others.

This conceptual research utilizes the General Systems Theory of Bertalanffy (1968) to explore the interconnectedness and interdependence of the systemic components. It supports the understanding of necessary roles for the system, the interests and needs of stakeholders, and the way decisions and actions are interconnected. The Ellen MacArthur Foundation defines circular economy as a closed-loop system that maintains products and materials in circulation. It utilizes innovative ways of creating and using products, extending product life, and exploring more useful applications of material using 9R strategies of refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover (Potting et al., 2017). It requires specific supply chain management, integrating the business processes from supplier to end-users that provides products, services, and information, with additional paths for managing outputs from end users back to the supplier or other stakeholders to maximize the use of resources and minimize waste. Studies of coffee-based industrial symbiosis include responsible coffee consumption (Maya et al., 2021) and coffee-based eco-industrial park design (Laili et al., 2024) related to coffee plantations. Compared to these investigations, this research is more holistic since it portrays broad collaboration of coffee shop chains as potential continuous urban-based coffee waste providers, with community-based consumers that are probably better educated and aware of circular economy. It seeks to show that the process optimization of closing the loop in the industry is achievable through industrial symbiosis with acceptable scalability. Therefore, it aims to develop a conceptual framework of industrial symbiosis as a form of system-level business model innovation drawing on the improvement of previously attempted examples.

RESEARCH QUESTIONS AND METHODOLOGY

The main question is how to encourage the transition from linear to circular economy within the Indonesian coffee shop industry through the implementation of industrial symbiosis. This goal is achieved through the development of a conceptual framework visualizing network design with the identification of stakeholders and potential resource processes to facilitate circular collaboration within the symbiosis. To answer it, this research combines a literature review and interviews with coffee shop owners, supported by case studies of recycled products offered by certain coffee shop chains in the form of coffee ground-based souvenirs, skincare products, and shoes, and an example drawn from the BAPPENAS program of eco-friendly cup-based practice at Anomali Coffee. Theoretical and empirical findings are subsequently combined to develop a network design that can logically visualize unrealized potential for the initiative, including burdens and rewards. The literature review is used to identify gaps in under-researched areas of this field, although this does not imply that every approach is novel due to the goal of visualizing the combination of drivers to encourage participation.

Three coffee shop owners in Bandung were chosen as respondents based on their relative willingness to embrace innovation. The first owns a single store coffee shop with strong connections to a coffee brewing community, located in a student-populated area of a nearby well-established public university. The second constitutes a green concept coffee shop which focuses on waste management and environmental sustainability with branches in Jakarta and Bekasi. The third is a single store coffee shop close to a renowned private university whose clientele are mostly young and with whom coffee shop culture is closely associated. The case studies include three types of recycled products obtainable from large coffee chains: coffee ground-based souvenirs and skincare products constituting a collaboration by an Indonesian coffee chain consisting of approximately 900 stores as of 2023, and shoes provided by a larger coffee chain with currently more than 1,000 stores. A pragmatist philosophy incorporates a combination of stakeholders' subjective perspectives and causal relationships in balancing both short- and long-term goals.

FINDINGS AND VALUES

The Anomali Coffee case shows that circular economy approaches do not always consider all existing potentials, possibly due to the scalability of the approach. However, it shows the importance of cost optimization and consumer demand for the continuation of the initiative by considering the values of business model innovation that drives competitive advantage in various forms. The conceptual framework then offers industrial symbiosis as an alternative expected to be highly valuable for involved actors, while achieving circularity. Compared to linear economy, the important component is the collaborative use of surpluses to reduce the environmental damage from the exploitation of raw materials and direct waste disposal. The concept of maintaining resources in the loop is implemented through the practice of circular supply chain management based on the symbiosis involving various stakeholders with their specific roles (Ahmad et al., 2023). Industrial symbiosis acts as the mechanism to realize the closure of the resources loop as it relates to recycling (Baldassare et al., 2019). Supported by the valorization potential of coffee shop waste (Mayson & Williams, 2021), the next important step is to identify the process components. These include the network of collaborating stakeholders, exchanged resources and valorization mechanisms, along with technological enablers (Ahmad et al., 2023), supported further by the result of the interviews to indicate the specific coffee shop-related approaches. The model also incorporates the combination of circular business models proposed by Lacy et al. (2020).

The research intends to encourage transition by positioning industrial symbiosis as a synergy-level business model with network infrastructure based on findings by Faria et al. (2021) and the systemic taxonomy proposed by Fraccascia et al. (2019) that also identifies value proposition, value delivery, and value capture of the business model (Richardson, 2008) which drive competitive advantage. The innovation is realized through the end products and other offerings related to consumers' participation (Borrello et al., 2020). Discussing incentives as a participation driver is important (Henriques et al., 2021), and the framework recognizes their value along with those of business model innovation. The interviews showed that potential competitive advantage can act as an incentive that drives stakeholders' participation. The extrinsic ones are viewed as a regulatory aspect, while the empirical evidence further suggests that the inclusion of regulations and supporting infrastructure, together with existing barriers, can further influence the burdens and rewards of participation for stakeholders.

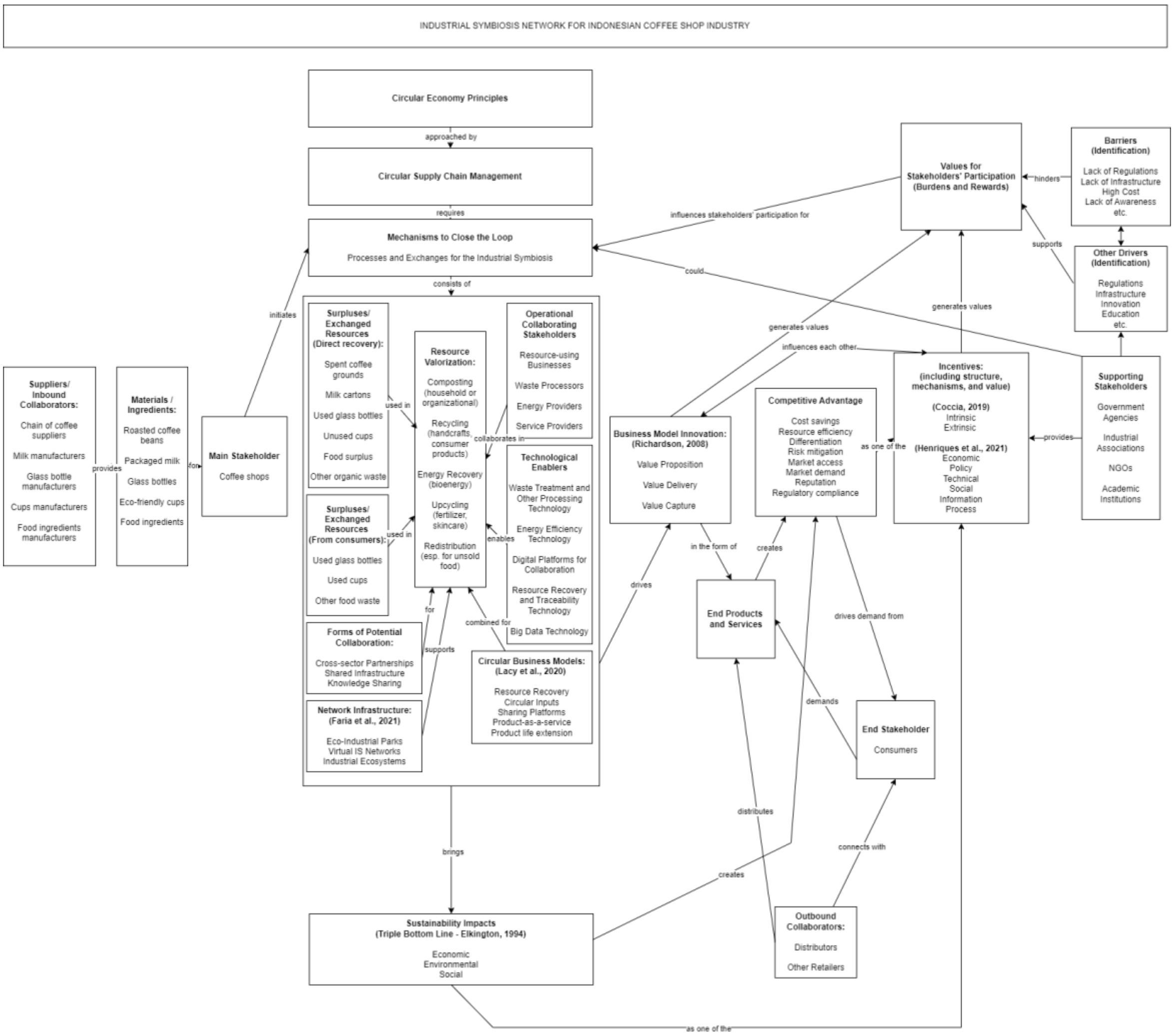

Figure 1. The Conceptual Framework of the Paper

In conclusion, industrial symbiosis was found not to be widely practiced in Indonesia, despite its function in promoting joint cost reduction and creating new business lines. The value of this research lies in the novel exploration of Indonesian coffee shops through the designing of an industrial symbiosis network to realize circular economy. This involved scalable collaboration, as presented in Figure 1, to help involved actors make decisions regarding their participation based on the research question. The conceptual framework is built around the coffee supply chain focusing on a coffee shop industry that is not entirely manufacturing-based. It can be used to recognize potential collaborators and their roles, exchanged resources and valorization, mechanisms and technological enablers, potential business model innovation and its value components, essential incentives, and possible sustainability outcomes and impacts on economic, environmental, and social aspects. This model has been developed on the basis of resource efficiency, waste reduction, and stakeholder engagement to highlight its scalability. It will provide researchers and practitioners with a framework of essential factors guiding the implementation of circular collaboration for the sector in an emerging country to maintain profitability, while contributing to the sustainability initiative.

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Assessing the Adoption Challenges of Green Procurement Practices in Central Hospitals: Case of Kamuzu Central Hospital and Queen Elizabeth Central Hospital

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1. INTRODUCTION AND RESEARCH BACKGROUND

Sustainability in business operations is increasingly becoming a priority for organizations across the globe. Green Procurement (also known as sustainable sourcing, sustainable procurement, green purchasing) can be seen as the ideal lever for sustainable development as it not only improves own environmental credential but also for suppliers as well. Green Procurement can be defined as *A process whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole-life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment*" (Force, 2006, p. 10) Traditional procurement mainly focus on cost, quality and delivery whereas green procurement also includes waste reduction, environmental impact while evaluating suppliers.

In recent years, research on green procurement has witnessed geometric expansion as evidenced by a bibliometric analysis by Kabra et al., (2023). 657 articles have been published from 2019 to 2022 on this topic. Despite the growth, the number of articles published in African context is extremely low. Existing research predominantly focuses on high-income countries or countries which are developing, where resources and infrastructure to support green procurement are more readily available. Malawi on the other hand is one of the poorest countries in the world and operate in resource scarce settings which presents unique challenges and opportunities for green procurement. Hospitals are major consumers of energy, water, and medical supplies, have a critical role to play in adopting sustainable practices. Adopting sustainable practices can significantly reduce environmental degradation.

The primary objective of this research is to examine the current practices, challenges faced by Malawian hospital employees in adopting green procurement. In doing so, this research will address the gaps identified by Kabra et al., (2023).

2. RESEARCH CONTEXT

Two of the five central hospitals in Malawi were the setting of this study. Kamuzu Central Hospital (KCH) located in Lilongwe and Queen Elizabeth Central Hospital (QECH) in Blantyre were chosen for this research because they are the largest hospitals in the country. Kamuzu Central Hospital has 1000 beds and at any given time they treat 1200 patients. Likewise, Queen Central Hospital has 1350 beds. (KCH, 2024; QCEH, 2024). Green procurement is a new concept in Malawi hence exploratory and explanatory research was undertaken. We conducted semi-structured interviews with 12 key personnel and a survey involving 109 employees from procurement, administrations, pharmacy, environment quality management unit, environment, and waste management.

3. LITERATURE REVIEW – GREEN PROCUREMENT

Kabra (2023) classifies current literature on green procurement can be broadly classified into four clusters as depicted in Fig 1. This research falls under Green Supply Chain Cluster. This cluster examines the role of regulatory environment, organizational factors, market pressures in shaping green procurement and sustainability outcomes. Typical studies in this cluster examines the relationship between sustainability initiatives and business performance, drivers and barriers for adoption and role of regulations. We explore current procurement practices in terms of adoption levels and challenges faced by multiple stakeholders in the hospital.

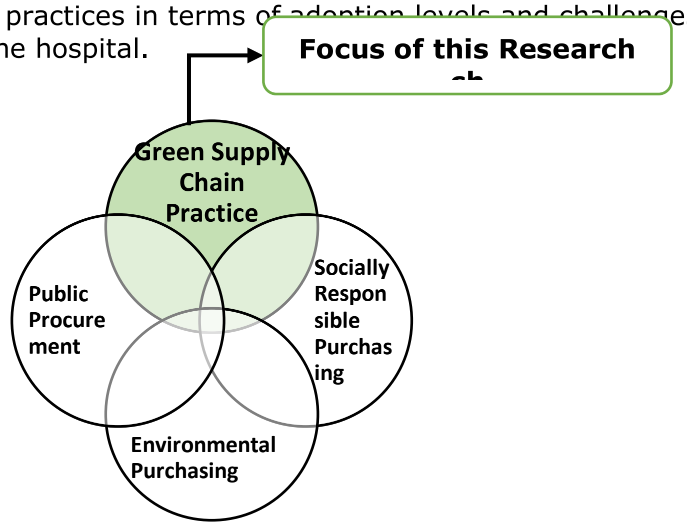

Fig 1: Key Research Themes related to Green Procurement
Adapted from Karba et al., (2023)

Green procurement practices, such as using eco-friendly products, recycled materials, and energy-efficient products, can reduce pollution (Opoku-Mensah et al., 2022). Orfanidou et al., (2023) argues that active stakeholder engagement can minimize implementation barriers and reduce disposal costs but the eco-friendly products generally costs more. Internally, Organisational Capabilities such as Employee competence (Chari et al., 2020), managerial levels (Mansi and Pandey, 2016) and and organisational processes, structures (Alkaabi and Aljaradin, 2023) have been found to have a positive influence on the adoption of green procurement. Internal capabilities combined with stakeholder pressure can force an organisation to adopt green procurement which starts with the development of green procurement specifications. Including environmental criteria in material purchase decisions and environmental criteria in tendering stage can positively impact the adoption of green procurement (Balasubramanian & Shukla, 2017). Environmental criteria can be classified into two groups – criteria related to product and criteria related to supplier. Green specification can be developed by collaborating with supplies and users in healthcare sector (Mayer at al., 2022). Adoption of green practices in hospitals can reduce cost as used products can be recycled. Moreover, developing sustainable specification minimize the use of dangerous materials (UNEP, 2015).

4. CHALLENGES IN ADOPTING GREEN PROCUREMENT PRACTICES.

Green procurement practices adoption often comes with lot of challenges. This is due to lack of funding, lack of stakeholder collaboration and lack of training (Mc cord., 2019). In addition, lack of management commitment for waste handling and extensive use of single use resources limits the implementation of green procurement in hospitals (Renjitha and Samuel, 2022). Furthermore, in Sub Saharan Africa, lack of government regulation and policies hinders management of bio medical waste (Oyebode et al.,2022). Technology, awareness of policy and supplier's lack of resources also affects the adoption of green procurement practices (Hanif and Musvoto, 2023). Moreover, monitoring supplier is difficult as most of the supplies are imported.

5. RESEARCH STRATEGY AND DATA COLLECTION METHOD

Self-administered semi- structured questionnaire and interviews were used to collect primary data, and published articles, journals, and reports were utilized to gather secondary data. To ensure a well-rounded exploration of the research topic, quantitative and qualitative methods was applied for inclusivity (Sardana, et al., 2023). Semi-structured interviews increased flexibility and explored more emerging insights. The participants were selected based on their knowledge, insights and perspective of the research topic (Rashid, et al.,2021). The respondents were from procurement, administrations, pharmacy, environment quality management unit, environment and waste management. Table 1 depicts respondent profiles of the research participants.

Sample	Sample Size	KCH	QECH	Data Collection Method
Administrators	2	1	1	Key informant interview (KII) guide.
Procurement	2	1	1	
Environmental	2	1	1	
Quality	2	1	1	
Waste management	2	1	1	
Pharmacy	2	1	1	
Total	**12**	**6**	**6**	
procurement /stores	13	6	7	Self-administered questionnaire.
Environmental	28	16	12	
Quality	6	4	2	
Pharmacy	39	21	18	
Waste management	44	24	20	
Total	**130**	**71**	**59**	

Table 1: Respondent Profiles

6. DATA ANALYSIS

Thematic analysis was used to analyze qualitative data and themes were categorized and differentiated manually. The investigator concentrated on the topic, hence capturing important information. To describe the characteristic and comparing the respondent results cross tabulation was used to analyse quantitative data. Chi square and Logistics regression was used teste the significant association of independent variable and dependent variable.

6.1 Procurement role in the Hospitals

Hospital procurement process guided by Public Procurement and Disposal of Asset (PPDA). It starts with capturing the user department need and formulating procurement plan. Bulk purchases are made based on Ministry of health budgets. The findings reviewed that KCH and QECH spend about 700,000,000 Malawi Kwacha each for medical items with demand surpassing supply. Despite demand exceeding supply, waste is generated before and after consumption. Findings indicates that non-availability of green procurement policy and lack of awareness about green procurement principles. However, due to few knowledgeable procurement officers, existing waste management policies and need to comply with donor's requirement, green practices are being implemented to some extent. The finding is in line with Guo, et al., (2020) that the experience of the procurement personnel in green issues matters most. This implies that procurement department can facilitate and increase awareness of green practices if green procurement policy is available in hospitals.

4.2 Green Specification

Green specification is incorporated in the procurement processes to an extent. However, it affects the lead time and due to the urgent nature of hospitals activities non green items which becomes challenging in waste disposal stage. Buying sustainable items need pre-planning to match with hospital operations. Procurement buys reusable consumables which reduces waste generation, however, the respondents pinpointed that more waste is created due to the nature of the hospital activities which requires disposable items to prevent infections.

Green practices such as recording temperatures and expiry dates are being implemented in these hospitals to increase safer and effectiveness of the drugs. However, lack of collaboration with donors brings drugs with short expiry date, including non-frequently used drugs creating waste quickly. The toxicity and long expiry of an item is specified bearing in mind the health of the patients and the environment. Therefore, hospitals need to balance the availability of drugs, safety, and waste by involving all stakeholders.

4.3 Green supplier selection

According to Yu et al. (2020) results, health sector does not use green criteria because of the nature of its operations. This is similar with this research as Malawian hospitals emphasize on cost rather that than environmental criteria like ISO14000 when selecting suppliers. It does follow international standards while developing specifications for medicines and equipment but does not use any green criteria while evaluating products and suppliers. The results also showed that hospital procurement team has developed good relationship with suppliers on items needed regularly but there's no discussion about sustainability. Thus, missing an opportunity of integrating environmental criteria from the source in the procurement processes

4.4 Waste Management Practices

Hospitals use biodegradable materials to some extent due their ease of incineration and decomposition. However, most of medical products are made of plastics which cannot be decomposed but only incinerated and produces black smoke which pollutes the air. These finding encourages hospitals to buy biodegradable materials to reduce environmental degradation.

Hospitals have implemented three bin system with colour codes to distinguish infectious, highly infectious and non-infectious waste. However, employees mix waste due to the mindset that once the product has been used, they don't care about its disposal. This requires the hospitals to bring in a fresh approach to enhance staff responsibility of waste management.

Nevertheless, there is lack of labour and personal protective equipment (PPE) which slows down the collection of waste producing unpleasant smell in the wards. This means availability of resource will improve waste management and the employees will be motivated to do the work effectively. Hospitals have environmental steward in the ward who takes charge of waste and environment resulting in minimal adoption of green practices. Despite these efforts, inefficiencies of incinerators result in partial incineration and waste buildup in dump area or open burning hinder the society and the environment. The in efficient of the incinerator causes waste not to be managed well hence new advance incinerators needed.

For drugs disposal, hospitals have a committee however, the process is long as it involves the approval from government and the last drug disposal happened in 2017 which made expired drugs to accumulate, prolongs the incineration, hence increasing costs. These results lead to environmental and health hazards requiring timely efficient disposal measures.

The findings pre-empt that respondent always consider cost and sometimes prefer quality over environment. Qualitative findings also stated that lowest bidder get the contract. Therefore, hospitals acquire cheap consumables non-reused, with short life and lack of collaboration with suppliers on environment product influences low levels of adoption. This needs balancing cost, environmental and quality aspects to implement green procurement practices. Procurement has appointed a contractor for waste collection and disposal but there is lack of enforcement of contractual terms from the perspective of safe disposal of drugs. Fig 2 (end of document) depicts the key findings from the interviews with various respondents in adopting green procurement practices.

4.5 Adoption levels of Green Procurement Practice

From the below table, it can be interpreted that the current adoption levels of green procurement practices is not high. Notable ones are 45% never / rarely collaborate with suppliers in waste reduction and around 47% prioritize cost over environment.

Adoption levels of Green Procurement Practice (No of responses (%)	Never	Rarely	Sometimes	Often	Always
Emphasize purchase of Reusable Products	23(21.1)	41(37.6)	21(19.3)	12(11)	12(11)
Emphasize purchased items to include eco-friendly packaging	24(22)	27(24.8)	35(32.1)	12(11)	11(10.1)
Undertake life cycle assessment of the product in terms of carbon emissions	27(24.8)	27(24.8)	29(26.6)	11(10.1)	15(13.8)
Give preference to local suppliers	13(11.9)	19(17.4)	45(41.3)	17(15.6)	15(13.8)
Emphasize the absence / reduction of non-toxic materials while purchasing items	14(12.8)	24(22)	34(31.2)	19(17.4)	18(16.5)
Specify limits on energy consumption	24(22)	18(16.5)	42(38.5)	12(11)	13(11.9)
Develop specifications that include sustainability component	16(14.7)	25(22.9)	43(39.4)	10(9.2)	15(13.8)
Prioritize quality over environmental impact	14(12.8)	13(11.9)	43(39.4)	25(22.9)	14(12.8)
Prioritize cost over environmental impact	15(13.8)	17(15.6)	30(27.5)	23(21.1)	24(22)
Collaborate with suppliers in reducing waste and develop environmentally friendly	23(21.1)	22(20.2)	32(29.4)	17(15.6)	15(13.8)

Table 2: Current adoption levels of green practices

4.6 Challenges in adopting Green Procurement Practice

Majority of the respondents, 55% reported that they strongly agree that challenges which are encountered are lack of information system, 45% lack of recycling capacity, 39% for lack of government incentives, 38% lack of green procurement strategy, 30% higher cost, prioritizing patients 32%, environmental awareness 29%, and lack of funding 27%. Table 3 provides more details about the findings.

Challenges in adopting Green Procurement Practice (No of responses (%))	Never	Rarely	Sometimes	Often	Always
Cost of environmentally sustainable products are higher	8(7.3)	14(12.8)	27(24.8)	27(24.8)	33(30.3)
Limited availability of environmentally friendly products	4(3.7)	17(15.6)	25(22.9)	34(31.2)	29(26.6)
Lack of funding	9(8.3)	17(15.6)	26(23.9)	27(24.8)	30(27.5)
Supplier not aware about green procurement practices	9(8.3)	21(19.3)	30(27.5)	26(23.9)	23(21.1)
Absence of green criteria on bidding document	5(4.6)	5(4.6)	46(42.2)	29(26.6)	24(22)
Prioritising patients over environment	9(8.3)	9(8.3)	18(16.5)	38(34.9)	35(32.1)
Lack of awareness about environmental impact of purchasing	5(4.6)	6(5.5)	17(15.6)	49(45)	32(29.4)
Lack of support from senior management	7(6.4)	9(8.3)	34(31.2)	34(31.2)	25(22.9)
Lack of pressure from other stakeholders like patients / NGOs	5(4.6)	13(11.9)	30(27.5)	29(26.6)	32(29.4)
Lack of capacity to recycle items	5(4.6)	12(11)	15(13.8)	28(25.7)	49(45)
Lack of green procurement strategy in the hospital	6(5.5)	8(7.3)	24(22)	29(26.6)	42(38.5)
Lack of incentives from Government in adopting green procurement policy	7(6.4)	12(11)	17(15.6)	30(27.5)	43(39.4)
Lack of appropriate Information System to support green procurement	3(2.8)	3(2.8)	15(13.8)	28(25.7)	60(55)

Table 3: Perceived challenges in adopting green procurement practices.

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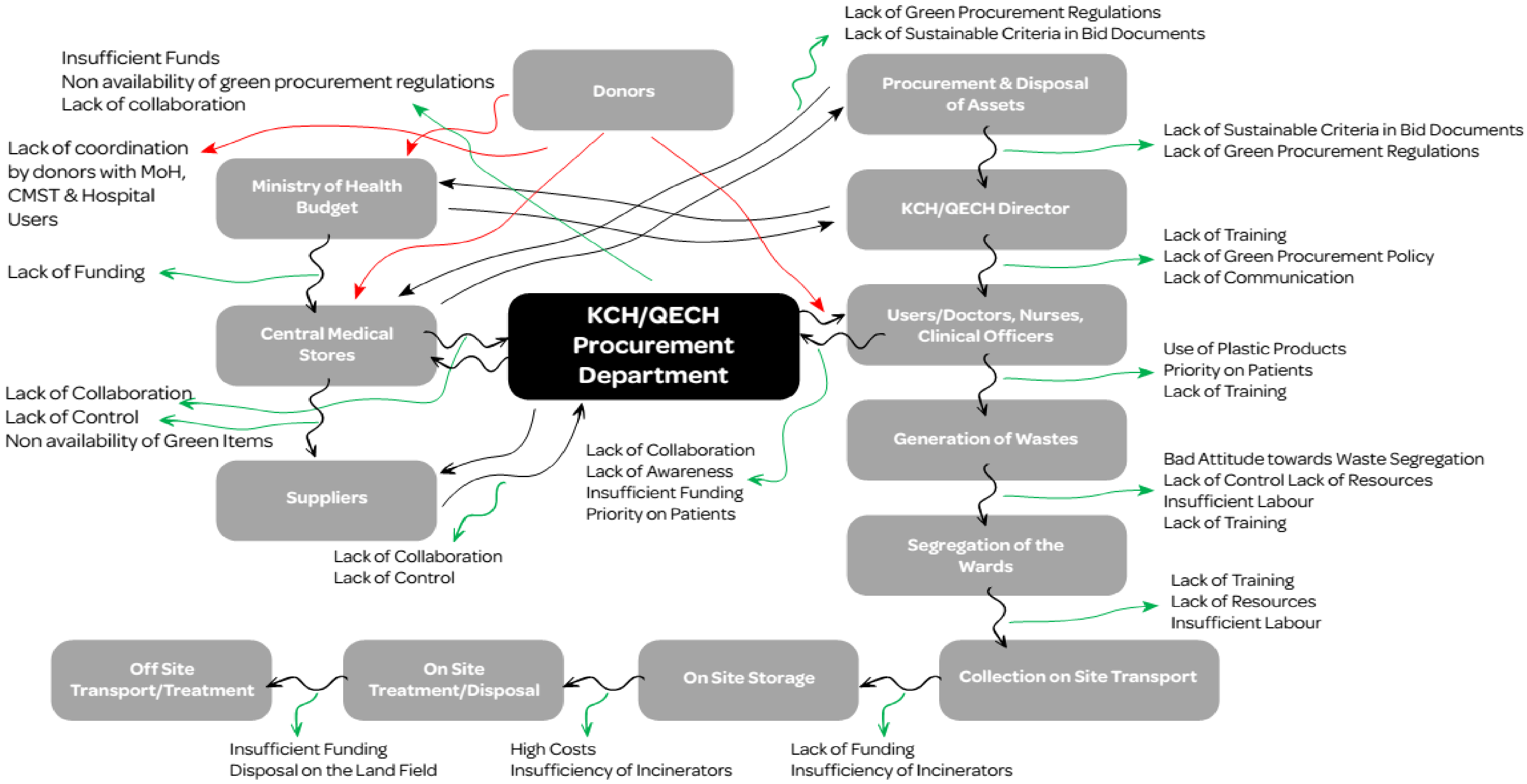

Fig 2 Challenges in implementing green procurement practices

Building Resilience for Supply Chains

Adoption of Traceability Technologies for Ensuring Food Security in the UAE

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ABSTRACT

This research focuses on the critical role of traceability technology in the food supply chain, particularly in the United Arab Emirates (UAE), where food security is a major concern due to the country's reliance on imports. The study's goal is to investigate the application of traceability technologies and blockchain in the UAE's food supply chain, as well as their impact on food security and consumer trust and behavior. The study proposes several hypotheses that can assess traceability technologies importance in food security resilience. A theoretical model has been proposed to understand the acceptance of technology in the food security systems. This necessitates the need for further investigation into food supply chain about the value of traceability and transparency in managing a complex food supply chain security and maximizing resilience performance.

Paper Type: Research paper

Keywords: *Traceability technologies, Food Security, Sustainable supply chain, Resiliency*

INTRODUCTION

The requirement for transparency and traceability is forcing a significant overhaul in the world's food supply chain. This transition is particularly important in areas like the United Arab Emirates (UAE), a country that imports a lot of food due to its climate which is arid desert being hot and dry. With the growth in both diversity and population, ensuring food security, food quality and food safety in the country has gained utmost significance. With minimal natural agricultural scopes, UAE imports about 90% of its food supply which has been a cause of concern for the country. However, the nation is gearing up to boost local food-production by providing initiatives and investments and transform the local food and beverage industry (FoodNavigator, 2023). The UAE has adopted new regulations to maintain a constant and stable food supply since it has identified food security as a major concern (UAE Ministry of Climate Change and Environment, 2023).

Broadly, Food traceability refers to tracking the movement of food supplies/ products and its ingredients through the supply chain, where the production, processing and distribution of food products is documented. Barcoding, RFID, and blockchain are just a few examples of the tools that are included in traceability technologies, which allow for the tracking and monitoring of food products as they move through the supply chain. The global food supply chain is using traceability technology more frequently because the traceability and transparency tend to decrease the food fraud and ensures the safety of the product (Food Quality & Safety, 2020).

The UAE is right at the intersection of being a global trade-hub and managing a complex food supply chain. Food security in UAE became a subject of concern as they have to balance the food imports and the fast economic growth with its inability for large-scale local food production. A typical food supply chain has various phases starting from sourcing of raw materials to processing or manufacturing and then to distribution retailers or end consumers, along with the best mode of transportation between these stages. Each stage is equally important and critical to keep the food supply chain functional (Al Sarqi, 2013). In the UAE, the food and beverage industry is growing at a rate of 5.13% annually while this industry is expected to generate $37.76 billion in revenues in 2023 (Statista, 2023). Despite the potential advantages of traceability technologies, very less has been explored in terms to what extent can they be implemented, how they really affect food security, and how they affect consumer behavior in the United Arab Emirates. Adopting, implementing and understanding their implications is the need of the hour within the food supply chain in UAE in order to cater to the ever-growing consumer expectations and ensuring food security. The following research questions has been designed:

- RQ1: How will traceability technologies help to improve food security in the UAE's food supply chain?
- RQ2: To what extent do traceability technologies help to enhance customer's trust and behavior in UAE's food supply chain?

LITERATURE REVIEW

Traceability technologies in food supply chain

As per Nainsi et.al, (2023) a traceability system in the food supply chain essentially aids to monitor the uncertainty of the food supply chain, which can be achieved through technological innovation. Various technologies like RFID, barcoding, sensing technologies and blockchain can assist to track the flow and history of food items from end-to-end in a supply chain. An efficient traceable system will provide all food related information from farm to fork. This would not only provide solutions to avoid food loss but also to reduce food waste. About 30% of edible food is lost or wasted in food supply chains globally in which 14% is lost post-harvesting stages, even before reaching the retailer. Because most food items are perishable, the food supply chain is very vulnerable and consumers are interested to know how and from where their food comes to them especially after the Covid-19 outbreak (Matzembacher, 2018) Traceability can be defined as documented evidence where all the necessary information (origin, environmental impact, social impact etc.) about food items from a farmer's farm to a consumer's place is available which would help consumers gain trust in the brand and also enable the authorities in food security and also food-recalls for health and safety reasons as well (Bosona and Gebresenbet, 2013). Bosona and Gebresenbet (2013) further highlighted that the food products can be checked for quality control at any time with the help of technology. However, Nainsi et.al, (2023) further stated that a United Nations body called FAO (Food and Agriculture Organization) has collaborated with Microsoft and IBM to develop AI techniques (artificial-intelligence) in order to reduce food wastage and detect negative practices. However, the authors also argue that there can be conflicts among stakeholders regarding investing in traceability technology according to their interests, which should be resolved as per trade-offs.

The physical location of the product in a food supply chain can be determined. Consumers are more interested in the food quality while the supply chain players like producers, distributors and retailers may seek different information from traceability tools. But, using more precise tools like digital tags can help consumers gain confidence and loyalty. Technology adoption in traceability of food supply chain is usually different in developed countries and developing countries, where a major consideration is capital resource and also the rules of the game are set by the players in power-position (Matzembacher, 2018).

Because the blockchain technology tracks ownership across the supply chain, consumers would be able to follow the information about the food product from farm to fork situations (Tsoukas et.al, 2022). Dong et al. (2023) have described in their study that by reducing the amount of good food that is wasted during movement and handling, using advanced traceability technology to track food in the supply chain can benefit all the stakeholders by increasing revenue. But, there's also a chance that wholesalers or distributors that purchase the food products from manufacturers could intentionally pay lesser by taking advantage of those who sell it directly to consumers. Large retailers may suffer as a result of this as the main burden of costs might be inflicted upon them. Furthermore, the way the supply chain is set-up influences how these advantages and risks are distributed. Also, partial tracking or improved supplier coordination may prove to be more beneficial than complete tracking in certain situations in order to mitigate risks.

Astuti and Hidayati, (2023) have mentioned that the food supply chain can benefit from increased traceability and transparency owing to the implementation of blockchain technology. However the authors argued that implementing this technology would be difficult due to factors including high prices, the requirement for greater understanding among all the stakeholders and rapid shifts in the food supply chain worldwide. Blockchain has the ability to greatly improve the tracking of food from farm to table, regardless of these obstacles. Ellahi et.al, (2023) have revealed in their study that the food supply chain is changing as a result of blockchain technology's increased efficiency and transparency. Traditional traceability techniques are insufficient in the face of globalization and technological advancements. The authors have added that blockchain technology, in conjunction with Industry 4.0 and Web 3.0, can enhance the sustainability and management of food supply chains by simplifying their monitoring and verification processes. Cao et.al, (2023) have reiterated that food supply networks can be made more trustworthy and sustainable with the application of blockchain technology. When compared to traditional approaches, this technology makes sustainability pledges more trustable by giving customers access to more dependable, verifiable and traceable information. Therefore, we propose the following hypothesis;

- ***Hypothesis 1****: Using sensing technologies and blockchain in the food supply chain can decrease the food waste and thus this can strengthen food security.*
- ***Hypothesis 2****: Traceability systems in the food supply chain can have significant positive effect on consumer trust and loyalty by offering comprehensive details on food origin, environmental factors and quality elements.*

Consumer behavior and impact of traceability technologies

Earlier, Rijswijk and Frewer (2012) have mentioned that consumer confidence in food safety and quality may be impacted by how they view food and its ingredients and decide what to eat based on it. Information through the traceable technologies should be made available to consumers and it has been observed that well-informed customers of the food supply chain also have a positive impact on their buying decisions. Mancini et.al (2017) have reiterated that a virtuous customer is one who gives attention to details about the food products information and encourages transparency in value chain in order to reduce the carbon footprint. Consumers are also prone to buy more organic food products when they are traceable (Xiang Wu et al 2021). The virtuous and well-informed consumer is more inclined to have quality and sustainability measures above offers or low prices that are being offered by retailers for their products. Implementation of blockchain and other technologies as a major factor to make buying decisions is higher in metropolitan cities as compared to rural areas.

Likewise, Ge (2022) has pointed out that consumer purchasing decisions in the food sector are greatly influenced by their understanding of food traceability, the accuracy of traceability data, and the reliability of traceability certifications. Elements like these impact customer's perceptions of the benefits and risks of traceable food, with social influence being a significant component as well. Yuan et al., (2020) also discovered degree of consumer knowledge regarding traceability technology also regulates this value perception, indicating that more well-informed consumers are going to value and buy traceable goods even more. The authors suggest that there is a necessity for the food industry and marketers to concentrate to educate consumers about traceability technologies. Therefore, we propose the following hypotheses;

- ***Hypothesis 3:*** *The availability of traceability information on food products positively influences consumer confidence and individual perception on food safety and quality which leads to more informed and positive buying decisions.*
- ***Hypothesis 4:*** *Consumers with higher awareness of traceability technologies are more likely to opt for quality over price and therefore will likely pay high premium*
- ***Hypothesis 5:*** *Consumer behaviour and trust can have a positive association food security resiliency*

Traceability technology and resilience in supply chain

Earlier, Wünsche et.al, (2022) have added that transforming the existing food supply chain through technologies can lead to resilience as there is greater visibility throughout the end-to-end process by preventing foodborne diseases, monitoring expiry dates, efficient resource planning and optimizing transportation routes and modes. Dash et.al, (2022) have also highlighted that food supply chains can benefit financially from the use of digital traceability systems, but only if expenses are split among all the stakeholders as it is a very expensive technology. Retailers and suppliers can share costs, but as retailers pay more, their profits decrease. The consumer will be willing to pay more for products that has traceability information but only up to a certain price point. These systems can be more beneficial if the consumers are aware of them, and government regulation is necessary to guarantee food security.

However, Shi et.al, (2023) have added that certain challenges like food product-recalls due to infections can be addressed quickly by retailers and thus reduce losses. In order to increase resilience, retailers have adopted different sourcing procedures, such as changing suppliers when risks are detected. Blockchain technology helps retailers, manufacturers, suppliers and customers to make timely and informed decisions. Therefore, we propose the following hypothesis;

- ***Hypothesis 6:*** *Implementing blockchain technology associated traceability system in the food supply chain improves stakeholder unity (suppliers, retailers, manufacturers, consumers) which helps to enhance overall resilience.*

Importance of implementing traceability technologies

According to Vasileios Tsoukas et.al, (2022) the food supply chain that are more sustainable, traceable and transparent may be built using blockchain technology. The information flow in the agricultural sector is more transparent and traceable thanks to digital distributed ledgers. This promotes secure real-time payments, recording and tracing transactions, and monitoring among all the stakeholders of the supply chain and reduce food wastes and frauds. Blockchain would also help in tracking with flow of goods, logistics (shipping alerts and receipts), connecting various items if they are lost through digital tags and sharing crucial information throughout the product's processing/manufacturing, distributing and maintenance.

Acciarini et.al, (2023) mentioned that digitalization and blockchain have been one of the major transformations in supply chains across the globe. Tracking and authenticating the flow of food products at each stage along with the nutritional values increases the sense of involvement of the consumers. It is a trusted and secure technology that positively influences consumer behavior. Haji (2020) has discussed in his article that traceability technologies help to enhance sourcing of raw materials, transformation and processing, packaging, shipping and selling of food products. Integration of technologies like RFID, blockchain, IOT increases traceability for suppliers, manufacturers and distributors and also traceability for consumers.

Sharma et.al, (2023) however mentioned in their article that blockchain is still evolving from an emerging to a more mature technology in the food supply chain. It increases revenues and trust among all supply chain members and reduces risk of fraudulent activities. However, lack of resources as well as training and educational platforms about the technology may reduce the main advantages, especially in the developing countries. Different consumer segments may have a different approach to traceability information and it is needed to give importance to different information preferences of the consumers.

With this assessment the following Hypotheses are formulated,

- ***Hypothesis 7:*** *Improved supply chain stakeholders' collaboration can significantly improve the sourcing, processing, and distribution of food products that can impact on food security resiliency*
- ***Hypothesis 8:*** *Implementing digital traceability systems in food supply chains leads to increased consumer willingness to pay a premium for products and this can moderate the consumer trust.*

THEORETICAL FRAMEWORK

This study thus formulated the following theoretical framework to assess the factors that affect the adoption of traceability technologies by UAE consumers in the food supply chain.

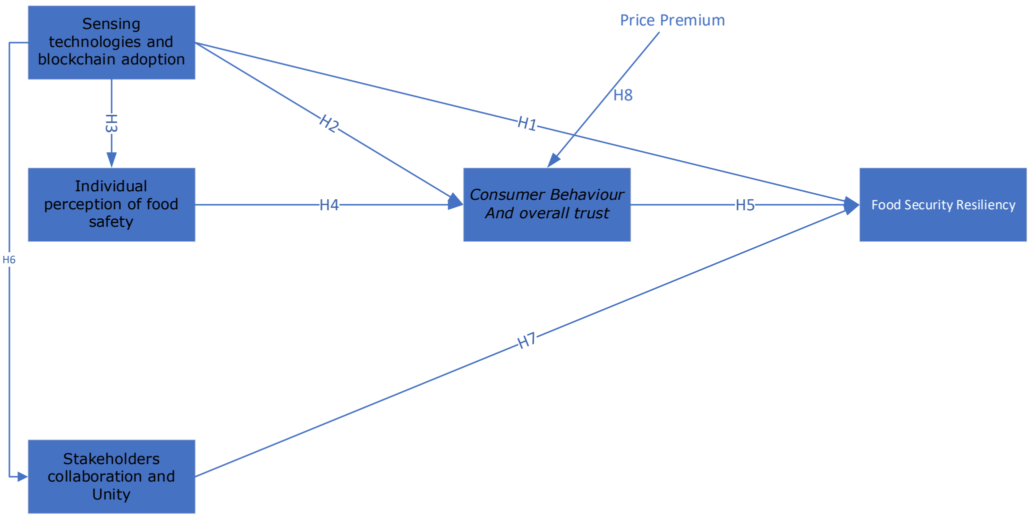

Figure 1: The theoretical model

RESEARCH METHODOLOGY

A structure questionnaire will be developed and used to design the construct of the IVs, DV and mediating variable by using Qualtrics software. The design of the questionnaire was believed to have an effect on the response rate as well as reliability and validity. Hussey and Hussey's (1997, p. 162) guidelines will be followed to ensure an adequate questionnaire with high reliability and validity. The questionnaire will be distributed taking purposive sampling among the selective food supply chain stakeholders in Dubai and refined further in order to comply reliability and validity.

PRELIMINARY FINDINGS THROUGH REVIEW

As the study is in the conceptual stage of the research design, survey distribution among the food supply chain stakeholder, sample collection, analysis and findings are the future extension of this research work. This research work is very significant because, consumers are curious about the food they eat as awareness about transparency and traceability has increased due to the influence of social media. However, the regulatory authorities in the UAE and some other countries have different compliance policies. Several problems to be addressed in this regard for the traceability technologies implementation as they

Data problems: It is difficult to reduce human error during data entry and to obtain reliable information from suppliers. If food products are not scanned accurately, it becomes difficult to trace them and extracting meaningful insights from the data presents further challenges.

Costs and trust: UAE food companies must safeguard their supply chains due to soaring costs. For trust to exist, it is essential for the retailers to know all the stakeholders involvement in supply, production and distribution. Investing in technologies and distribution of costs and risks among these players poses as a challenge.

Food product traceability and food safety: Although it is challenging due to the harsh weather and reliance on imports, the UAE government closely monitors food quality. There is ample of food that gets contaminated or wasted during transportation and also storage if it is not handled properly, before reaching the end consumer. Using a single all-inclusive traceability system which may not necessarily be regulated by the government is a challenge.

Blockchain challenges: Educating about blockchain and getting all the stakeholders on the same page is the biggest challenge especially when the regulations are uncertain. Successful implementation of blockchain requires parties to communicate effectively and to align their interests. This is a barrier, but both the public and private sectors are ready to adopt this technology for the greater good.

Environmental impact: It can be difficult to strike a balance between technological adoption and sustainability objectives. There may be environmental consequences from some traceability technologies, so it's critical to discover environmentally acceptable alternatives. Since RFID tags are usually disposable, it is important to recycle them appropriately. Metals and plastic are used to produce it which can impact the environment and since they require electricity to function, their energy consumption can be substantial.

CONCLUSION

To conclude, this research paper outlines the critical role that traceability technologies play to improve the food supply chain in the UAE. The review indicate that small retailers face many challenges and would prefer simple and affordable techniques while the larger ones would actively adopt these systems. Retailers also revealed that the UAE food supply is still not technologically advanced and still crawling towards it, with a few stakeholders taking lead. The literature review indicates that the impact of social influences and consumer knowledge on technological adoption is apparent, but there is still a lack of execution in the mainstream. Consumers definitely want to know details about the food they consume from farm to fork. This study not only enhances our understanding of traceability technologies in the UAE but also paves the way for future research in areas such as economic impact and policy effectiveness. This study recommends future scope of study that could help all the stakeholders of the food supply chain to improve efficiency, in addition to improving our knowledge of traceability technologies in the United Arab Emirates.

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Investigation factors affecting Agri-food waste in Retailers entities: Evidence from Egypt

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1. Introduction

Despite significant progress in addressing global hunger, the Food and Agriculture Organization reported that nearly 690 million individuals or 8.9 percent of the world's population [1] still considered suffering from malnutrition Furthermore, The World Food Program 2020 identified 135 million people as experiencing severe food shortages [2]. The COVID-19 pandemic has recently resulted in a severe food crisis and a catastrophic worldwide economic recession. The FAO estimates that between 773 and 822 million individuals will undernourished due to the pandemic [3].

The pandemic poses a severe threat and challenge to food systems due to the convergence of movement restrictions, lockdown measures, and international trade closures [3]. This is especially evident in the disruptions that occur to food supplies and the general unpredictability associated with agri-food demand [4]. Amidst the escalating apprehensions, global initiatives such as "Moving forward on food loss and waste reduction" and "Save food" have gained attention [5]. Hence, the mitigation of food loss and waste [2] has become a global priority Especially in the agri-food sector furthermore, it directly aids in the attainment ″f Sus‶ainable D″velopment Goals first eradicating hunger and second promoting responsible consumption and production in developing countries [6].

Agriculture in the world represents a critical sector same as Egypt's economy and social fabric [7]. The sector employs 27.5% of the labor force and supports the livelihood of 55% of the population. As of 2020, the agro-food sector contributed 11.50% to the GDP and represented 17% of national exports [8]. However, food waste could negatively affect the sector, decrease national revenues, and fuel social instability. Rapid population growth, along with limited freshwater resources and arable land [9], is placing greater stress on Egypt's rural and urban food systems in terms of quantity, and in terms of changing food preferences towards high value, fruits that are more perishable and vegetables [4].

Therefore, food needs are growing rapidly in Egypt, especially for perishable products. The FAO estimated food waste to reach 45-55 percent of production annually [10]. A study conducted in Egypt by FAO estimated the quantitative loss of over 45 percent of grapes and over 50 percent of tomatoes in the production, retail, and wholesale stages of the value chain alone, along with a serious quality loss [8]. Retailers are obligated to provide sustainable services in food supply chain value to deal with wastages [11]. Returns Food waste in retail establishments is the result of neglecting to utilize sales such as last-minute marketing or price reductions for substandard, low-quality food products, according to several studies [12]. Insufficient stock rotation on shelves and the necessity to exhibit substantial quantities of food products to meet consumer demands are additional elements that contribute to food waste during the retail phase [13]. The research aims to explore the main factors affecting food waste within downstream entities in the supply chain in the Egyptian retail market considering two major retailers; The first retailer is a hypermarket called Carrefour one of the largest multinational retailers originally located in France, the other retailer Fathallah Market whose considered the oldest retailer and widely spread in Egyptian market.

2. Literature Review

The study investigates supply chain value concentrating on the distribution and retailing phase to investigate the appropriate characterization of food waste management. Previous studies show there is a lack of practical practices with stakeholders and the literature [14], despite the issue gaining increasing international attention [15]. Although certain stakeholders make a clear distinction between "food loss" and “food waste,” others fail to distinguish between the two [1], presuming that any food designated for human consumption that exits the food system automatically qualifies as wasted [16]. There is a multitude of factors contributing to the formation of food waste throughout the various phases of the food supply chain concerning its amount [17].

Estimating food waste in the distribution retail sector is a challenging endeavor [18]. This is the result of a considerable multitude of factors influencing the situation, including accounting approaches, corporate policies, management practices, and national and local legislation [19]. These factors may influence the availability and accessibility of stakeholder data, which may ultimately affect the accuracy of food waste estimations. As an illustration of the bureaucratic intricacy of the matter [20].

Consequently, the retail sector contributes a comparatively lesser amount to the overall accumulation of food waste in the context of national food supply chains [21]. Even so, it is crucial to guarantee that this current state of affairs does not mislead stakeholders, and there are many justifications for examining the matter of food waste in retail stores and future attempts to reduce it [22]. To begin with, groceries house an extensive assortment of perishable food items within a comparatively compact space. Therefore, they serve as the most suitable case studies for examining strategies in food waste management [23].

Furthermore, the retailer’s position is in a strategic location at the core of national food supply chains, serving as a link between producers and consumers [5]. Meanwhile, Companies in the Agri-food processing industry strive to avoid returns and rejected loads whenever possible [24]. Every return that occurs in the food supply chain is treated as a unique individual transaction, and therefore, these returns tend to have higher operational downtime and expenses. Therefore, many major retailers seek to provide accumulative services to minimize wastage [22].

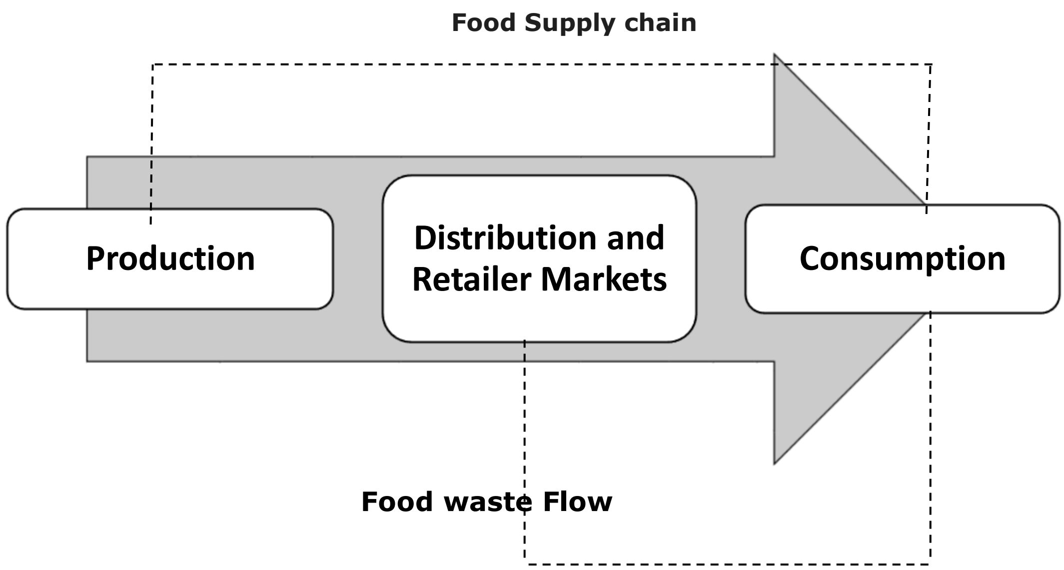

Figure 1: Agri-Food Waste Framework

The agricultural waste in Egypt gained a lot of attention to eliminate main issues for instance climate change, poor practices, and absolute techniques [25]. Less Agri food retail Market size is estimated at USD 5.20B in 2024 and is expected to reach USD 6.09 billion by 2029, growing at a CAGR of 3.20% during the forecast period (2024-2029) according to the Egyptian Ministry of Commerce. Therefore, Egypt has enacted 24 distinct legislative acts on food waste and sustainability [8]. A study prepared by the Food and Agriculture Organization [3] showed that about 50 percent of vegetables and fruits, 40 percent of fish, and 30 percent of milk and wheat are wasted annually in Egypt, (FAO,2022). Therefore, the distribution and retailer stage is a crucial point in supply chain value [26]. Notably, studies identify expired best-before dates broken packaging, and poor handling as primary reasons for wastage [27]. The study explores the applicability of circularity in the retail sector and the main factors of two major retailers in the Egyptian market Therefore, this research addresses the discus gap of food waste in retail sector by investigating areas where there is currently limited understanding or explored.

3. Research Methodology

This study provides a literature review on agri-food loss and waste management over the supply chain activities in developed countries to formulate the research problem. The previous literature focuses only on investigating the causes of food waste in the distribution and transportation process meanwhile a few studies discussed the food waste in retail sectors. However, this study uses exploratory, descriptive, and analytical methods. It explores the root causes of food waste in the retailing business and describes a phenomenon in a real-life situation by interviewing retailers in the agri-food sector and analyzing the results of the interviews to identify the significant root causes and effective actions to minimize and eliminate food waste using the available resources. Research's main objective is as follows:

- is RO1: Investigating the Retailing activities in Egypt.
- RO2: Identifying the root causes affecting agri-food waste in the retailing sector.
- RO3: Explore practices for eliminating and mitigating the loss and waste in retailing agri-food sector.

A multiple-case study research strategy was used to identify the causes of food waste in retailing activities as shown in Figure 2, especially in large retail chains. In particular, 12 case studies were investigated in Egypt, and the interviews were conducted with the following partners in the Retailing sector: in this case the retailers responsible for transportation, inventory management, and distribution duties. The diversity of the selected case studies assisted the researchers in examining the common and significant causes of food waste next stage will demonstrate the research methodology used in this study to achieve the research objectives.

A semi-structured interview method was used, as it is a qualitative method of analysis that combines a predetermined set of closed and open questions that encourage respondents to answer in detail. It also combines aspects of traditional and behavioral interviewing techniques and supports the use of empathic communication, such as paraphrasing [28]. Meanwhile paper considered the waste amount in each retail branch to define relation between sales to waste The researchers conducted 12 interviews with the following different partners in the retail sector: 2 managers, 3 executive managers, and 7 workers.

The semi-structured interview includes 36 questions, and the data collected were divided into the following three sections:

- Section One: Supply chain design and process. The answers gathered in this section helped the research to draw the agricultural food retail chain.
- Section Two: Percentages of waste and the root causes of agri-food waste. The answers provided helped the study to identify the root causes.
- Section Three: Recommendation In this section, authors collect interviewee opinions and suggestions

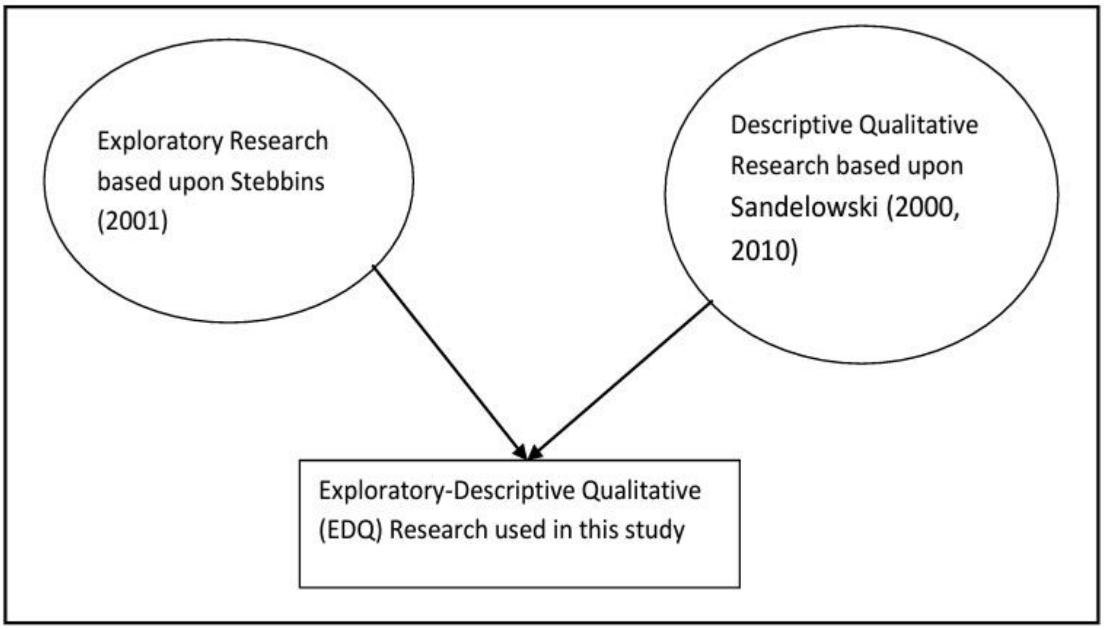

Figure 2: Expletory-Descriptive Approach (EDQ)

The findings of the interviews were analyzed qualitatively. The researchers used the following EDQ tools:

- Root cause analysis (RCA) is a process optimization instrument utilized to identify the underlying cause of a problem. Subsequently, corrective measures are implemented to eradicate the identified cause, thereby preventing its recurrence or transfer to another process [29]. Utilizing RCA has the following benefits: it facilitates direct problem discussion and the development of long-term improvements, and it simplifies the identification and analysis of root causes.
- Meanwhile, our research considered the waste and sales quantities in each retail branch to define a relation between sales to waste in 24 different branches 14 for MR1 and 10 for LR2 data assembled to get insights of relationships between sales and waste.

4. Results and discussion

The study contains two major retailers in Egyptian markets first one Carrefour is a French multinational retail (MR1) corporation. The eighth-largest retailer in the world by revenue, it operates a chain of hypermarkets, grocery stores, and convenience stores, which as of January 2021, comprises 12,225 stores in over 30 countries [30]. Carrefour Egypt was launched in Egypt in 2002. Today Carrefour operates 15 branches and employs over 6,000 employees. Carrefour City Centre Alexandria city branch opened in 2003, currently, it is ranked 3rd place in waste compared to all branches in Egypt. The second retailer is Fathallah companies are Egyptian local retailers (LR2) businesses that started their commercial activities in 1948. The beginning came with the second generation of the family by opening the first branch of Fathalla Market, which caused a stir in the world of direct selling to the consumer, as it was the first supermarket to sell to the consumer at the wholesale price. It was also distinguished by the diversity of goods, seriousness of dealing, and respect for the consumer, leading to a series of openings until it reached 31 branches in Alexandria and other governorates.

Descriptive analysis

The sales and waste percentage analysis were as follows: The correlation is a statistical technique that quantifies the association between variables describing the strength and direction of the relation. Spearman correlation coefficient is going to be applied to quantity the strength between waste and sales. Spearman correlation coefficient is selected for such evaluation rather than the Pearson correlation coefficient, as the sales data has been collected as a decreasing percentage of the total percentage of each case study. Hence, the data was already ranked.

Table 1. MR1 waste and sales correlation

Correlations						
			MR1		LR2	
			waste	sales	waste	sales
Spearman's Correlation	Waste	Correlation Coefficient	1.000	-.607*	1.000	-.697*
		Sig. (2-tailed)	-	.021	-	.025
		N	14	14	10	10
	sales	Correlation Coefficient	-.607*	1.000	-.697*	1.000
		Sig. (2-tailed)	.021	.	.025	.
		N	14	14	10	10
*. Correlation is significant at the 0.05 level (2-tailed).						

In the previous table, Spearman's coefficient shows a value of -0.607, indicating that there is an indirect moderate correlation between sales percentage and waste percentage. That means the higher the attained sales percentage the lower the waste percentage. In this case, the estimated correlation coefficients are said to be significant at a significant level of ɑ 5%. The significant level of the estimated coefficient in Carrefour branches is 0.021. Which would support the hypothesis of the existence of such a relation between sales and waste.

As same as MR1, Table 1 explains the result has been holding when the data of the ten branches of LR2 is analyzed. However, Spearman's correlation coefficient shows a value of -0.697, which indicates a stronger correlation between waste and sales. Also in both cases, the estimated correlation coefficients are said to be significant at a significant level of ɑ 5%. The significant level of the estimated coefficient in LR2 branches is 0.025. Which would support the hypothesis of the existence of such a relation between sales and waste.

Table 2. MR1 waste and sales coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	[31]	.965	.147		6.582	.000
	sales	-.049	.020	-.581	-2.472	.029

a. Dependent Variable: waste

The determination coefficient $R^2 = 0.3373$ which means specifically this factor (Sales) can affect waste by 33%, and the other factors can affect waste by 67%, factors such as training, display of products, packaging, and forecast.

Regression equation: Y (Waste) = -0.0492 X (Sales) + 0.9653

Variable x has an indirect relation with y. An indirect significant effect of sales on waste at significant level α = 5%, 0.029 is less than the significant level α = 5% so there is a truly significant effect of sales on waste.

Table 3. LR2 waste and sales coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	[31]	3.769	.806		4.678	.002
	sales	-.221	.122	-.565	-1.810	.113

a. Dependent Variable: waste

The determination coefficient $R^2 = 0.3187$ which means specifically this factor (Sales) can affect waste by 31%, and the other factors can affect waste by 69%, factors such as packaging, purchasing behavior, and forecast as shown in table 4.

Regression equation: Y (Waste) = -0.2206x (Sales) + 3.7688

Variable X has an indirect relation with y. An indirect, but insignificant effect of sales on waste at a significant level α = 5%. Significant at 0.113 is more than the significant level α = 5% so there is an insignificant effect of sales on waste.

Table 4. Descriptive statistics for MR1 and LR2

	MR1		LR2	
	Waste	Sales	Waste	Sales
Mean	0.6933	6.6867	2.56	6.43
Range	1.3	13.5	3.3	4.8
Minimum	0.3	1.1	1.2	4.5
Maximum	1.6	14.6	4.5	9.3
Q1	0.4	2.7	2.05	5.475
Q2	0.6	4.6	2.5	6.25
Q3	0.9	11.5	2.9	7.375
N	15		10	
R^2	0.33		0.31	

In the case of the MR1 Box-Plot of waste, it was shown that Q1= 0.4, Q2= 0.6, and Q3= 0.9 are located on the right side of the data range which means all branches excluding the extreme one, generate low waste. On the other hand, LR2 Q1= 2, Q2= 2.5, and Q3= 2.9 are located on the right side of the data range which means all branches excluding the extreme one, generate high waste. The qualitative research approach In Multinational retailers the first quartile (Q1) 25% of the total number of branches generate waste lower than 0.4, and (Q2) shows 50% of the total number of branches generate waste lower than 0.6, less than 75% of data fall below the third quartile (Q3) of branches generate waste lower than 0.9. While all of the branches generate waste, lower than 1.2 except branch 14, which has the extreme value of waste by 1.6. Meanwhile, In local retailers the first quartile (Q1) 25% of the total number of branches generate waste lower than 2.05 and (Q2) explained there is 50% of the total number of branches generate waste lower than 2.5 and (Q3) shows there is 75% of the total number of branches generate waste lower than 2.9. While all of the branches generate waste, lower than 3.2 except branch 6, which has the extreme value of waste by 4.5.

Synthesizing of food waste factors across the retailing sector

The second section investigates the main factors in the Egyptian distribution and retailing market, First organizational factors are classified into three categories: employee-related factors, organizational characteristics, and management, which may differ depending on the type of organization. Staff-related factors. Several studies have found that employees receive insufficient instruction on proper food disposal. In addition, staff members are unaware of the amount of food wastage both retailers highlighted the following and will rank by importance.

Table 5. Main Findings

Multinational retailer (MR1)	Local retailer (LR2)
The distance from the producer to the retail market	Handling practices
Staff shortage	The distance from the producer to the retail market
Dehydration	Temperature
The limited time available to effectively handle food waste.	Product Packaging
Temperature	Short shelf-life
Short shelf-life	Proper management and shelf order
Product Packaging	Dehydration
Lack of the adverse effects of food waste	Absence of Staff drive and target
The deficient instruction of staff in regard to the appropriate disposal of food or food products.	The deficient instruction of staff in regard to the appropriate disposal of food or food products.
Human errors	Lack of the adverse effects of food waste

According to the literature review, there was a link between food waste and operational factors Food waste can arise at several stages of the operations, such as strategic planning, purchasing goods, production, cleaning, serving, storing, or inventory management. Inadequate storage practices also contribute to food wastage. Marketing research aspects contribute to bridging the gap between customer expectations and product quality standards, hence reducing food waste.

5. Conclusions

This paper has analyzed food waste and the factors that contribute to food waste in the Egyptian retail market and practical practices. As a result of the major findings to the applicability of the research purpose on both Multinational retailers and local retailers, it was found as follows : For MR1, the Mean was 6.7 for sales and 0.7 for waste. While LR2 was 6.4 for sales and 2.6 for waste. The results also showed a huge difference in the waste generated in MR1 relatively low compared to LR2 which is much more and higher than Carrefour. The results also showed that there is an opportunity to improve especially in the sales since 'R^2' in MR1 was 33% and in LR2 was 31% which means that the sales factor only can affect waste by 33%. Meanwhile in Carrefour by 31% alongside with other factors.

The classification of the findings also highlights significant theoretical and managerial ramifications. Initially, it enhances the existing understanding of food waste that takes place at various stages of the food supply chain, such as retailers, food services, and the overall supply chain. This is achieved by conducting a thorough assessment of the present state of knowledge of the factors that contribute to food waste. Furthermore, it provides guidance for future research designs by identifying the deficiencies in the existing body of literature concerning the entities involved. Furthermore, it highlights inconsistent results in the existing literature regarding the impacts of food waste causes.

In terms of management consequences, this review enhances current understanding by categorizing the elements that contribute to food waste within the context of an organization's environment. Understanding the impact of an organization's environment on food waste generation is essential for waste prevention and the development of sustainable solutions. The categorization of the food waste elements in this analysis is anticipated to enable stakeholders to tackle the problems.

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MILES: Enhancing Perishable Agri-food Cold Supply Chain Management through a Newly developed Multimodal Integrated Logistics Environment for Simulation

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INTRODUCTION

The term "food cold-chain" (FCC) is a specialized subset of the broader "cold chain" (CC), focusing on preserving the quality of perishable foods (Cerchione et al., 2018). The objective of managing the food cold-chain is to maintain perishable goods at suitable temperature and humidity levels, safeguarding them from contamination by harmful microorganisms (Joshi et al., 2011). The food cold-chain encompasses activities from the farm to the consumer. The fundamental elements of a typical FCC infrastructure comprise pre-cooling facilities, containers, refrigerated carriers, packaging, cold storage facilities, and track-and-trace measurement tools. (Montanari, 2008). The cold chain is crucial for ensuring the safety and longevity of various consumables, including medicinal products, plasma, flower petals, fruits and vegetables, seafood, processed animal-flesh products, milk products, frozen foods, and more (Wu et al., 2019) and efficient management of the FCC can yield benefits for all stakeholders in the supply chain, the associated businesses, their customers, and the general public (Akram et al., 2023). According to the FCC framework, value addition refers to the strategic process through which a company enhances its market share, builds a positive reputation, prioritize quality, freshness, and health necessitates and improves cash flow by prolonging the shelf life of perishable food items and minimizing post-harvest losses (Oncioiu et al., 2019).

The global demand for value-added food has witnessed a substantial increase in the past decade (Naylor et al., 2021). Measuring the performance of the food cold-chain presents unique challenges compared to other supply chains (León-Bravo et al., 2021). The complexities arise from the need to maintain diverse temperature levels for various products during transportation across different modes. Particularly in developing economies, firms may encounter obstacles due to constraints related to FCC, such as limitations in infrastructure, costs, access to electricity, advanced technologies, and expertise (Joshi et al., 2011). According to (Kumar et al., 2020), China and India, being among the most populous and rapidly developing countries, also rank poorly globally in preventing post-harvest food losses attributed to inadequate food cold-chain performance. This contributes to heightened food insecurity and malnutrition (Mwaniki & Nyamu, 2022). In addition, Sub-Saharan Africa is identified as the most impoverished and nutritionally deficient region globally (Cerchione et al., 2018), could experience a significant economic gain of $40 million annually with just a 1% reduction in food waste (Lau et al., 2021). Additionally, the annual CO2 cost due to food waste is approximately 3.3 billion tons (Panahi et al., 2022).

The surge in global demand for food with added value has intensified the reliance on in cooling systems. The growing demand for air conditioning and refrigeration, particularly in rapidly developing countries facing climate change, complicates the environmental crisis. The environmental and climate impact of hydrofluorocarbons (HFC) refrigerants, coupled with the indirect emissions from energy consumption in cooling systems, heightens the urgency to address these issues. The current state of cold-chain infrastructure in developing countries, characterized by inadequate capacity and inefficiency, poses a substantial barrier to achieving agri-economic and nutritional goals. Therefore, this paper outlines a critical problem in the intersection of energy efficiency (EE) and HFCs and emphasizes the extreme need for sustainable solutions in large-scale. The primary contribution lies in proposing a strategic project, the 'Africa Centre of Excellence for Sustainable Cooling and Cold-Chain' (ACES), to address the challenges in Rwanda and extend it to East and Southern Africa. This project aims to accelerate the transition to sustainable refrigeration, reducing food loss and CO emissions. The paper underscores the potential of a newly developed Multimodal Integrated Logistics Environment for Simulation (MILES) which is object-oriented Java programming-based and developed by using agent-based modelling principles. It is a suite of tools and data structures made up of several Java artifacts, each of which contains several packages of classes for different use cases and deployments. Results demonstrates that this proposed platform is so efficient to be used for making large-scale strategic decision and dynamically test and plan interventions – changes in need/demand/price, new technologies and climate risks, aiming to significantly reduce cumulative emissions and waste by 2050. This aligns with Sustainable Development Goals (SDGs) and supports global climate commitments.

LITERATURE REVIEW

In recent studies, the integration of simulation technologies within agri-food supply chains have significantly contributed to modeling and enhancing efficiency, effectiveness and resilience. (Aiello et al., 2012) conducted a simulation analysis of cold chain performance based on time-temperature data, underscoring the importance of simulation in evaluating cold chain operations. Similarly, (Saif & Elhedhli, 2016) illustrated the application of simulation-optimization approach to design cold supply chains with environmental considerations, illustrating the practical application of simulation in optimizing supply chain operations. Moreover, (Mo et al., 2022) focused on partner matching mechanisms in cold chain logistics using Vensim software and emphasizied the role of simulation in enhancing logistics processes. (Zhu et al., 2014) employed Flexsim software to optimize the operation process of cold-chain logistics distribution centers, showcasing the utility of simulation in improving operational efficiency.

Furthermore, (Verawati et al., 2022) utilized AnyLogic to simulate queue systems in a port setting and demonstrated the versatility of simulation software in various logistical scenarios. (Van Der Vorst et al., 2009) underscored the importance of simulation modeling for food supply chain redesign and focused on integrated decision-making across product quality, sustainability, and logistics. (Madamba et al., 2022) developed an agent-based simulation model to study cross-contamination in lettuce processing and incorporated temperature fluctuations during storage. (Taghikhah et al., 2021) focused on integrated modeling of extended agri-food supply chains and highlighted a systems approach to address environmental pollution and greenhouse gas emissions. (Utomo et al., 2018) examined applications of agent-based modeling simulation in agri-food supply chains and demonstrated use of simulation techniques for modeling complex supply chain dynamics.

In addition, (Huang et al., 2021) conducted a simulation study to predict the impacts of the COVID-19 pandemic on food supply chains and their sustainability and showcased the effectiveness of simulation models in analyzing supply chains under uncertain conditions. (Ganesh Kumar et al., 2017) provided insights into the application of AnyLogic in agricultural supply chain management through a literature review. (Nakandala et al., 2017) modeled information flow and sharing matrices for fresh food supply chains, showcasing the potential of AnyLogic in analyzing and optimizing information sharing within supply chain networks. (Minegishi & Thiel, 2000) illustrated how system dynamics could enhance our understanding of the complex logistical patterns in an integrated food industry. (Vostriakova et al., 2021) offered scientific validation of theoretical and methodological principles of simulation modeling and developed practical recommendations for enhancing the agri-food logistics distribution system.

(Gallego-García et al., 2023) introduced a digital twin model aimed at improving smallholder resilience to crises like COVID-19 by using simulation technologies which assesses risks and policy impacts on the farmer's organization, supply chain, and environment to optimize the agri-food supply chain and ensure long-term viability. (Gailan Qasem et al., 2023) using a simulation-optimization approach, found to significantly reduce total costs—comprising holding, deterioration, ordering, and shortage costs—compared to the alternatives, despite its higher ordering costs. (Spiker et al., 2023) utilized a discrete event simulation model to analyze the effects of increased horticultural crop production on the efficiency of vegetable supply chains in Odisha, India, focusing on key vegetables like potato, onion, tomato, brinjal (eggplant), and cabbage.

(Malik et al., 2022) discussed the application of popular toolkits like AnyLogic, NetLogo, and Repast which can be adopted for demonstrating food supply chains production process in agent-based modeling. (Li et al., 2014) centered around the sustainable food supply chain management emphasized the role of simulation in addressing the uncertainties and risks within the food supply chains. (Railsback et al.,

2006) offered recommendations for agent-based simulation platforms, including tools like NetLogo, which can be beneficial for modeling complex behaviors in food supply chains. (Leithner & Fikar, 2019) developed a simulation model to explore how quality data can improve operations within organic fresh food supply chains. (Tsiamas & Rahimifard, 2021) proposed a simulation-based decision support system to enhance the resilience of food supply chains, providing a practical approach to mitigating risks.

These references collectively contribute to understanding the role of simulation software in optimizing food supply chain processes, addressing sustainability concerns, managing temperature along the cold chain, enhancing efficiency and providing insights into enhanced decision-making. Broadly, the utilized simulation techniques can be categorized into 1) montcarlo simulation[4], 2) system dynamics (SD)[5], 3) discrete-event simulation (DES)[6] and 4) agent-based modeling (ABM)[7]. Using these simulation techniques in Anylogic, Netlogo, Repast, Flexim, Simul8, etc offers a robust framework for modeling, analyzing, optimizing and addressing the complexity of systems across agri-food supply chains. They enable the examination of systems from different perspectives, offering insights into the dynamics, uncertainties, behaviors, and strategic interventions that can lead to improved outcomes and more informed decision-making. However, employing these conventional simulation software programs for large-scale perishable agri-food supply chains, especially in real-world cases such as regions in Africa, often faces challenges related to scalability, integration, and investigating the whole system's response to any changes in the state of each agent. So, we need to have a tailored solution designed to overcome the specific challenges faced by conventional simulation software programs in the critical sector of perishable agri-food supply chains including scalability issues, integration difficulties, speed limitations, lack of transparency and dependency on third-party software. Table 1 illustrated all the simulation software programs which have been utilized in agent-based modelling.

Table 1. Simulation software programs for ABM

Software for ABM	**Modelling Environment**		**Uncertainty & Stochastic Functions**		**Scalability**			**Visualization Capabilities**	
	GUI-based	**Other**	**Fully**	**Limited**	**large**	**Medium**	**small**	**2D**	**3D**
AnyLogistix	*			*	*	*	*	*	*
AnyLogic	*	with options for scripting	*		*	*	*	*	*
NetLogo	*			*			*	*	
Simul8		with options for scripting	*		*	*		*	*
Simio		with options for scripting	*		*	*		*	*
GAMA		GAMA Modeling Language	*			*	*	*	*
SCM Globe	*			*		*	*	*	*
Ascape		with options for scripting	*			*	*	*	*
Repast Simphony		JAVA	*		*	*	*	*	*
MASON		JAVA	*		*	*	*	*	*
JADE		JAVA	*		*	*	*		*
FlexSim		C++	*			*	*	*	*
ExtendSim		.NET	*			*	*	*	*
StarLogo		Logo-based language	*			*	*	*	*
Mesa		Python	*			*	*	*	
FLAME GPU		GPU-centric		*		*	*	*	
Swarm		C	*			*	*	*	
AgentPy		Python	*				*	*	

[4] Monte Carlo Simulation is a statistical technique that allows for the exploration of variability and uncertainty within complex systems. It relies on repeated random sampling to compute results, making it particularly useful for risk assessment and decision-making under uncertainty.

[5] System Dynamics (SD) provides a holistic approach to understanding the nonlinear behavior of complex systems over time. Using stocks, flows, feedback loops, and time delays, SD models allow for the simulation of scenarios to study the impact of different strategies on system behavior.

[6] Discrete-Event Dynamic Systems (DEDS) focus on modeling systems where state changes occur at discrete points in time, often driven by specific events. This approach is well-suited to operations research, logistics, and supply chain management, where the sequence and timing of events critically impact system performance.

[7] Agent-Based Modeling (ABM) simulates the interactions of autonomous agents (individuals or collective entities) to assess their effects on system dynamics. ABM is particularly valuable for exploring complex adaptive systems, where emergent behaviors and patterns arise from the interactions of individual components.

The rest of this paper is structured as follows: Section 3 delves into the problem definition, Section 4 outlines the proposed solution and its advantages, Section 5 summarizes the conclusions, and Section 6 lists the references supporting our research.

PROBLEM DEFINITION

The Africa Centre of Excellence for Sustainable Cooling and Cold-Chain (ACES) is at the forefront of addressing the critical need for sustainable refrigeration in Rwanda and the broader African context. This initiative is part of a transformative movement that advocates for the adoption of sustainable cold chain solutions to significantly reduce food loss and CO2 emissions and also improve health targets and export levels. By proposing the development of a virtual model, ACES aims to facilitate the strategic installation of new cold chain infrastructures capable of operating under a multitude of environmental scenarios. The model aspires to meet Rwanda's mission-driven social and economic targets, fortify the financial stability of smallholder farmers, underpin robust business models, and strategize on energy usage to mitigate emissions. Additionally, the model is designed to incorporate resilience against future shocks (increased temperature, change in seasonal patterns, inaccessible roads, price spikes, etc) and integrate comprehensive data structures, such as product specifics, storage logistics, and agricultural strategies that encompass all facets of cold chain planning and management. This holistic approach is a key to realizing a sustainable cold chain system that aligns with Rwanda's vision for a greener, more sustainable and more prosperous future.

The approach for simulation of this complex real world agri-food supply chain network needs to have some capabilities including: 1) sophisticated, 2) bottom-up designed 3) scalable, 4) self-organized, 5) Agent-based, 6) Fast in large-scale, 7) Transparent, 8) self-contained and 9)cost-effective. Therefore, employment of conventional simulation software programs, often face challenges when it comes to scalability, integration, and investigating the whole system's response to any changes in the state of each agent. They may struggle to handle large-scale input data in a reasonable time and may not integrate well with advanced modeling frameworks for complex databases. So, we need to have a tailored solution designed to overcome the specific challenges faced by conventional simulation software programs in the sector of perishable agri-food supply chains including:

- Scalability issues, where simulations cannot effectively process large volumes of data or expand to accommodate growing system complexities.
- Integration difficulties, making it hard to synchronize with other modeling frameworks or secure databases.
- Speed limitations, where simulations run slower in large-scale, affecting their ability to deliver timely results for decision-making.
- Lack of transparency, often seen with commercial software where the user is unable to access or modify the software's basic code for customization or troubleshooting.
- Dependency on third-party software, which can lead to issues with software maintenance, updates, or licensing that impact simulation availability and performance.

These challenges can impede the effectiveness of simulating complex supply chains, especially in regions with less developed technological infrastructures.

PROPOSED SOLUTION

The proposed solution is developing an innovative **Multimodal Integrated Logistics Environment for Simulation (MILES)**, a robust platform developed through object-oriented Java programming and grounded in agent-based modeling principles. MILES represents a cutting-edge approach to logistics simulation, characterized by its bottom-up, self-organizing structure that facilitates intelligent decision-making. This virtual model leverages a country's specific datasets to precisely analyze and refine cold-chain systems for food safety, as well as the associated cooling mechanisms.

Constructed as a comprehensive suite of tools and data structures, MILES is composed of multiple Java artifacts. Each artifact, in turn, contains a variety of class packages, each designed for distinct use cases and deployment scenarios. This agent-based modular framework allows for the tailored application of MILES across different contexts and requirements, offering a versatile and dynamic solution to optimize the cold-chain logistics essential for preserving perishable goods. The agents that have been considered in the model has different locations and roles based on Fig 1. In the architecture of the MILES model, considerations for vehicle specifications, product characteristics, and order details as different agents are integral. These agents are carefully factored into the design to ensure a comprehensive and realistic simulation environment. Utilizing the ACES pull model, powered by the innovative MILES platform, we've conducted a techno-economic optimization analysis to determine the most effective network of cooling hubs for the preservation and distribution of agricultural produce in Fig 2. Our model has been tasked with facilitating the logistics for 10,000 tonnes of sorghum, with the demand equally split between the Kigali airport and the Rusumo border crossing. The predictive capabilities of MILES have suggested the strategic placement of hubs to the north and south of the Kigali sink, ensuring optimal access and resource allocation. Additionally, MILES has advised a two-step distribution process to efficiently manage the flow of goods near Rusumo. This tailored arrangement, is poised to enhance the preservation quality and ensure timely delivery, significantly boosting our distribution efficiency in the region.

Therefore, MILES provides a tailored solution designed to overcome the specific challenges faced by conventional simulation software programs in the critical sector of large-scale perishable agri-food supply chains, offering a comprehensive toolset for robust and flexible supply chain management. It is scalable, capable of handling large input decks with the support of university-hosted server resources, ensuring that complex simulations can run without the constraints of limited computational capacity. It is self-organized and agent-based modeling features enable intelligent decision-making, where autonomous agents interact and influence each other, reflecting the dynamic nature of real-world supply chains. MILES's speed advantage means it can perform complex logistics simulations significantly faster than off-the-shelf software, offering a time-efficient alternative for simulation needs. Its transparency is another key benefit; being open-source allows users full access to probe, refactor, debug, and reuse the code, enhancing the adaptability and longevity of the simulation tool. Furthermore, MILES operates offline as a self-contained system, independent of third-party software maintenance, which ensures reliability and continuity of operations. This aspect of MILES eliminates the vulnerability associated with external software dependencies that could affect the simulation's availability or performance. Lastly, owning the intellectual property of MILES frees users from licensing constraints, allowing unrestricted use and customization to meet specific needs of the perishable agri-food cold supply chains in larg-scales. This level of freedom is essential for continuous improvement and innovation in supply chain management, especially in areas where the infrastructure may not support commercially licensed software.

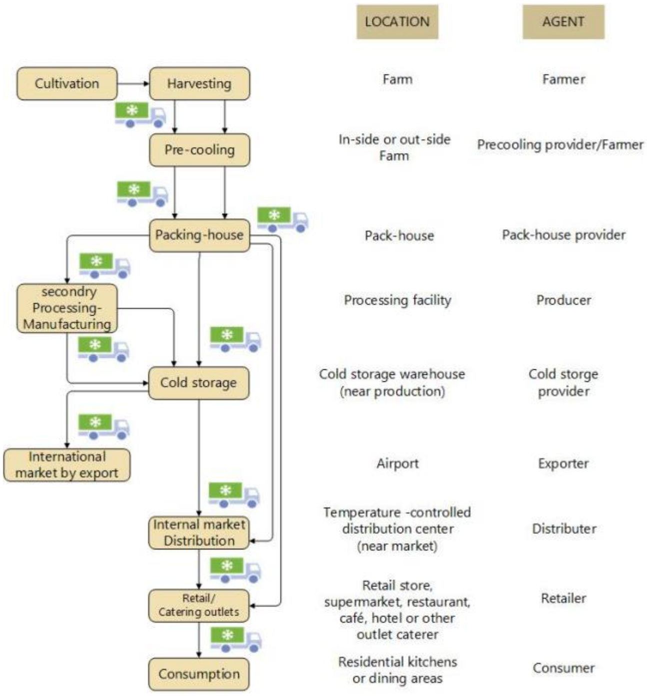

Fig 1. Considered perishable agri-food supply chain flow diagram and contributing agents

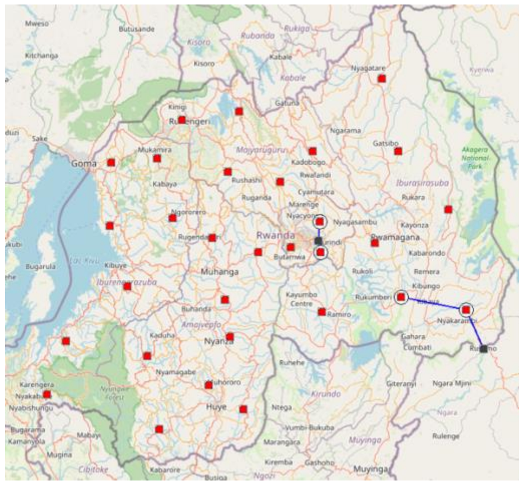

Fig 2. Optimized Cooling Hub Network for Enhanced Agricultural Produce Distribution using MILES

CONCLUSIONS

This paper underscores the critical importance of addressing the challenges within the large-scale food cold-chain (FCC) sector, particularly in regions like Rwanda where infrastructure, costs, and technological expertise pose significant hurdles. Through the Africa Centre of Excellence for Sustainable Cooling and Cold-Chain (ACES), the paper advocates for the transition to sustainable refrigeration as a solution to reduce food loss, CO2 emissions, and improve health outcomes and export levels. Additionally, the introduction of the newly developed Multimodal Integrated Logistics Environment for Simulation (MILES) offers a tailored approach to overcome the limitations of conventional simulation software programs in managing perishable agri-food supply chains.

MILES, developed through object-oriented Java programming and agent-based modeling principles, stands as a sophisticated tool capable of addressing the unique challenges faced in optimizing cold-chain logistics. Its bottom-up, self-organizing structure, and scalability allow for intelligent decision-making and efficient handling of large-scale simulations, essential for managing the complexities of real-world perishable agri-food supply chains. Furthermore, MILES offers transparency, speed, and independence from third-party software, ensuring reliability, adaptability, and freedom for continuous innovation and improvement. By embracing sustainable refrigeration solutions and leveraging advanced simulation technologies like MILES, stakeholders can work towards a greener, more sustainable, and prosperous future for the perishable agri-food sector in Rwanda and beyond. This developed platform is in the start of its journey and we consider evolution sprints for it including 1) design, 2) operationalization, 3) scalability, 4) cyber physical infrastructure and CPI connectivity and 5) digital twin.

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Factors Influencing Tourists for Selecting Thailand as a destination after the COVID-19 Pandemic

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INTRODUCTION

COVID-19, which is a natural disaster, has caused a global impact on political, economic, and socio-cultural systems (Aigbedo, 2021; Mihajlovic, 2020). The restriction of daily individual, social, organizational, and public activities was under heavy control. Physical mobility was temporarily postponed and lockdowns(Dwivedi et al., 2020; Papadopoulos et al., 2020). The tourism supply chain (TSC) also has been hit by COVID-19. In total, the pandemic resulted in a loss of 2.6 billion international arrivals for the combined years of 2020, 2021, and 2022, nearly double the number of arrivals recorded in 2019(*International Tourism Highlights, 2023 Edition – The Impact of COVID-19 on Tourism (2020–2022)*) shown in Figure 1.

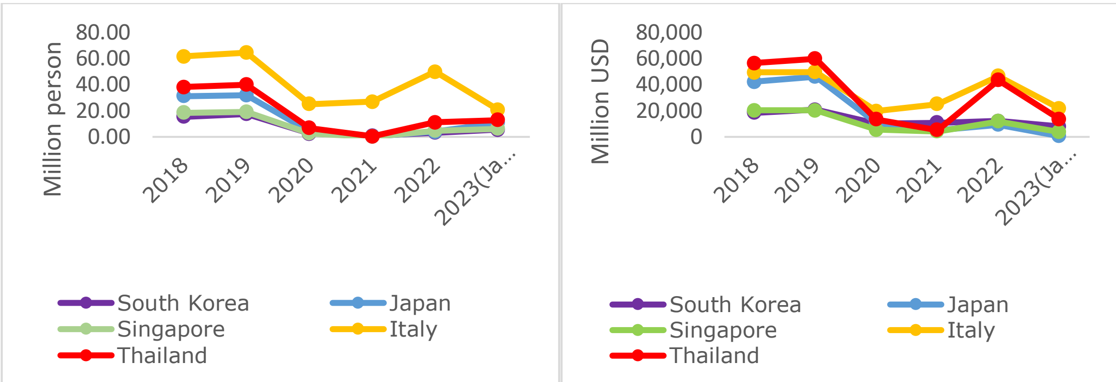

Figure 1 The number of international arrival tourists (left) and total tourism revenues (right) in selected countries

Thailand was in the top ten countries in total international arrival tourists(*International Tourism Highlights, 2023 Edition – The Impact of COVID-19 on Tourism (2020–2022)*). In 2019, the Thailand tourism industry contributed to around 18 per cent of Thailand's total Gross Domestic Product (Statista., 2023). There has however been a sharp decline in the GDP of the tourism industry since 2020, reaching only 5 per cent. By the end of 2023, the total number of tourists has not reached the expectation set during the same period before the onset of COVID-19(Ministry of Tourism & Sports.).

To boost up the number of international tourists after the COVID-19 pandemic, a campaign named 'Amazing New Chapters' was launched to establish Thailand's tourism industry in a more sustainable and responsible direction. However, the decision to select Thailand as a destination may be changed by the effect of the COVID-19. For instance, social media influences tourists' decision-making in consuming nightlife tourism in Phuket, Thailand, as well as in other spending areas (e.g., accommodation and shopping)(Phucharoen et al., 2023). Smart technology has also become one of the competitive factors in Thailand's tourism industry. E-service quality can consistently meet customer needs, offering "online shopping" and enhancing information communication for tourists, which can build positive customer relationships(Jaruwit, 2023). This paper therefore aims to identify the factors that significantly impact tourists' decision-making regarding Thailand as a destination after the COVID-19 crisis.

RESEARCH METHODOLOGY

Papers selected for this review have been published in various international journals listed in EBSCO and Elsevier. Keywords used are "tourist decision-making, " "tourist travel motivation, "tourist decision-making, Thailand, " and "tourist decision-making, COVID-19, " etc. Selected papers published from 2001 to 2024 were investigated. Eleven international journal papers relevant to selecting Thailand as a destination were chosen and the period of publishing was before the COVID-19 situation. Twenty-three international journal papers were published after the pandemic occurred, covering various countries and types of tourists. The content analysis has been conducted to analyse the similarities and differences of influencing factors for tourists to select a travel destination.

RESULTS

Before the COVID-19, the decision-making process of tourists in choosing a destination is influenced by eight factors including security and safety, finance, travel experience, infrastructure, product and service, and culture and heritage as shown in Table 1.

Security refers to the protection of tourists and their belongings from external threats, focusing on individual safety. Safety encompasses aspects related to health, accidents, natural disasters, and other incidents not caused by human actions(Bentley et al., 2001; De Nardi & Wilks, 2007). The importance of safety and security significantly influences tourists' decision-making and travel experiences, because many tourists who perceive risk as confronting are likely to avoid unsafe tourism products(Rittichainuwat et al., 2001). Suanmali (2014) described that financial factor as the cost of staying, which includes transportation, food and so on. (Thiumsak & Ruangkanjanases, 2016; Yiamjanya & Wongleedee, 2014)emphasized travel experience as the significance of creating memorable experiences, and it plays a crucial role in influencing an individual's decision to revisit a location.

The product and service factor includes tourist satisfaction, sustainable issues, the value of service quality for customers, restaurant service quality, and customers' perceptions in terms of service quality (Lertputtarak et al., 2014; Tsai et al., 2016). Tourism destinations can be defined as a main part of tourism products(Fard & Saberi, 2015; Yiamjanya & Wongleedee, 2014). Tourism products can be both intangible (such as experiences) and tangible (including hotels, restaurants, etc.)(Sangpikul, 2008; Siri et al., 2012).

Sastre and Phakdee-Auksorn (2017) agreed that culture evokes tourists' interest in travel, stating that 'learning new cultures' and 'interest in Thai culture' are major factors that impact international tourists' decisions to visit Thailand. The cultural resources of a destination are one of the factors that attract tourists and influence their decision-making(Taecharungroj & Mathayomchan, 2019).

Authors	Destination	Tourists	Safety and security	Travel experience	Infrastructure	Product and Service	Culture and Heritage	Finance
(Rittichainuwat et al., 2001)	Thailand		✓	✓		✓	✓	✓
(Sangpikul, 2008)	Thailand	Japanese	✓		✓	✓	✓	
(Sastre & Phakdee-Auksorn, 2017)	Thailand	British	✓			✓	✓	
(Yiamjanya & Wongleedee, 2014)	Thailand			✓		✓	✓	✓
(Siri et al., 2012)	Thailand	Indian		✓		✓	✓	✓
(Thiumsak & Ruangkanjanases, 2016)	Thailand		✓	✓		✓	✓	
(Tsai et al., 2016)	Thailand	Taiwanese	✓	✓		✓	✓	
(Suanmali, 2014)	Thailand				✓	✓	✓	✓
(Fard & Saberi, 2015)	Thailand					✓	✓	✓
(Taecharungroj &	Thailand			✔		✔	✔	✔

Mathayomchan, 2019)								
(Lertputtarak et al., 2014)	Thailand	Russian		✔	✔	✓	✓	✔

Table 1 Factors on Tourists' Decision to select Thailand as a destination

Paper published after the COVID-19 pandemic occurred as shown in table 2. By comparing different countries and types of tourists, it has been found that factors influencing the selection of a travel destination have increased, particularly social media and smart tourism technology.

Authors	Destina-tion	Tourist	Safety and security	Social media	Travel experience	Infra-structure	Product and Service	Smart tourism technology	Culture and Heritage	Finance
(Wen et al., 2021)		Chinese	✔		✔	✔	✔	✔	✔	
(Hao et al., 2021)		Chinese	✔			✔		✔		
(Li et al., 2021)		Chinese	✔				✔	✔	✔	
(Villacé-Molinero et al., 2021)			✔	✔	✔		✔			✔
(Pappas & Glyptou, 2021)	Greece		✔				✔			
(Wang et al., 2021)		Korean	✔	✔			✔			
(Kim et al., 2022)	HongKong USA		✔				✔			✔
(Itani & Hollebeek, 2021)		American	✔				✔	✔		
(Park et al., 2021)	New Zealand		✔		✔		✔		✔	
(Seong & Hong, 2021)	Korea		✔			✔		✔		
(Bratić et al., 2021)		Serbian	✔	✔	✔		✔			✔
(Cong, 2021)		American	✔	✔			✔	✔		
(Mihai et al., 2023)	Romania		✔		✔		✔		✔	
(Alkier et al., 2023)	Europe		✔		✔	✔	✔			✔
(Phucharoen et al., 2023)	Thailand		✔	✔			✔			✔
(Cheng et al., 2024)		East Asia		✔	✔		✔		✔	
(Woyo & Slabbert, 2023)	Southern Africa		✔		✔	✔	✔		✔	
(Shabankareh et al., 2023)	Iran			✔		✔	✔	✔		
(Ong et al., 2023)	Philippines		✔	✔	✔					
(Soltani-Nejad et al., 2024)				✔	✔		✔			✔
(Deng et al., 2023)	Macau			✔	✔		✔		✔	

(Hermanto et al., 2023)	Indonesia				✔		✔	✔		
(Luekveerawattana, 2024)	Thailand					✔	✔	✔	✔	✔

Table 2 Factors on Tourists' Decision-making during COVID-19

Smart tourism technology

According to Neuhofer et al. (2015),Smart Tourism Technology (STT)refers to specific applications that enhance tourists' experiences and provide additional value for customers. For instance, the widespread adoption of the Internet of Things (IoT) includes Virtual Reality (VR), Augmented Reality (AR), integrated payment methods and social media, etc(Huang et al., 2017). STT allows stakeholders to gather dynamic tourist data and help the operators design and offer more personalized services to tourists(Jeong & Shin, 2020). During the pandemic, tourists showed an interest in using virtual reality tours to help choose their travel destinations for the post-pandemic period(Itani & Hollebeek, 2021). Establishing face recognition systems, robot cleaners, and contactless consulting platforms is beneficial for offering intelligent services to tourists (Li et al., 2021).Hermanto et al. (2023) agrees that the use of digital payments enhances tourists' satisfaction, particularly due to the convenience these payments offer during their travels.

Social media

According to Zeng and Gerritsen (2014), social media has three definitions that are 1) it encompasses online tools, applications, platforms, and media, relying on information technology, 2) peer-to-peer communication channels, fostering interactive web content creation, collaboration, and exchange among participants and the public, 3) it connects users, forming a virtual community through cross-platform interactions influencing people's behaviours and real-life experiences. Wen et al. (2021) noted that tourists' travel behaviours are influenced by obtaining information and sharing travel experiences through online platforms. TripAdvisor online reviews not only influence tourists' intentions to revisit but also affect their experiences, recommendations, and satisfaction(Soltani-Nejad et al., 2024).
From the literature review, the major tourists' influences can be categorized into four dimensions shown in Table 3.

Dimensions	Factors	Indication
Travel risks	Safety and security	High standards of hygiene, cleanliness, and lower risks regarding health issues are preferable.
	Finance	Tourists prefer small-scale tourism and focus on the price-quality nexus due to the economic regression caused by the pandemic
Attractiveness	Smart tourism technology	Visitation data can efficiently improve local services such as crowd control and transportation control. The employment of smart travel solutions, such as VR-based tours, maintains tourists' interest.
	Culture and History	Historical heritage is one of the important factors influencing international travellers.
Quality	Product and service	The quality of food, accommodation, and transportations are key drivers behind tourists' choices of travel and destinations. The quality of healthcare services can importantly influence tourists.
	Infrastructure	Tourists are interested in destinations with sufficient medical facilities/hospitals.
Information	Social media	Communication platforms are available to ensure useful information for tourists publicly.
	Travel experience	Young people are now likely to travel abroad. They would love to search for travel experiences from international destinations and they also love to revisit if they have a good travel experience at their destination.

Table 3 Four dimensions relevant to factors on tourists' decision-making.

CONCLUSION

There is a series of factors that influence the decision of tourists to choose Thailand as their travel destination. Factors can be summarized into four dimensions, namely- travel risk, attractiveness, quality, and information acquisition. Each of these factors can be divided into two sub-factors, including safety and security, finance, smart tourism technology, cultural and heritage, product and service quality, infrastructure, social media, and travel experience. The change in the factors can be seen clearly by the comparison of the two groups of papers. Before the pandemic, only a few studies highlighted the role of infrastructure, social media, and smart tourism technology. In contrast, post-pandemic researches indicate that infrastructure, particularly public facilities and health equipment, has become a crucial factor in influencing tourists' decision-making. Social media provides quick information about destinations and builds tourists' trust through communication. Moreover, the pandemic's restrictions on people's mobility have led to the development of new technological solutions in the tourism industry to maintain tourists' interest and ensure tourists' safety. Compared to travel experiences before the pandemic, where tourists were primarily driven by their intention to gain international experience, the post-pandemic period exhibits a shift in focus. Tourists now consider a broader range of travel experiences, both external and internal factors, in making their travel decisions.

Although the factors have been proposed, the refinement of the factors will be conducted in future along with the mapping between the factors and Thailand's tourism supply chains. A policy recommendation for Thailand's tourism supply chain could then be analysed and proposed.

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Navigating the New Disruption: Enhancing Resilience in the Automotive Supply Chain

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INTRODUCTION

In the contemporary landscape of global commerce, supply chains represent the intricate web of interconnected entities responsible for the efficient flow of goods and services from raw material suppliers to end consumers. However, this complex network is vulnerable to disruptions, as evidenced by the profound challenges faced by the automotive industry during the recent "New Disruption" period, marked by the unprecedented COVID-19 pandemic (Ahlqvist et al., 2020). The automotive sector, renowned for its reliance on just-in-time manufacturing and extensive global supply networks, experienced significant upheavals that underscored the critical need for enhanced resilience strategies (Guan et al., 2020).

This paper delves into the realm of supply chain resilience (SCR) within the automotive industry, focusing on how organisations navigated the challenges presented by the New Disruption and sought to fortify their operations for future uncertainties. Employing a methodology anchored in case study analysis supplemented by focus group discussions and interviews, this research seeks to provide a comprehensive understanding of the strategies, adaptations, and lessons learned by automotive supply chain stakeholders amidst tumultuous times.

The significance of this study lies in its contribution to the broader discourse on supply chain management and resilience. By examining the experiences of automotive industry actors, this research aims to unearth valuable insights that transcend sectoral boundaries, offering actionable recommendations applicable to diverse supply chain contexts. As supply chains increasingly face an array of disruptions ranging from geopolitical tensions to natural disasters and pandemics, the imperative to bolster resilience has never been more pronounced (Chowdhury et al., 2020; Moosavi and Hosseini, 2021).

Against this backdrop, the remainder of this paper unfolds as follows: following this introductory section, the subsequent sections will review relevant literature to establish theoretical foundations and contextualise the research within existing scholarship. Subsequently, the methodology section will delineate the research approach, detailing the rationale behind the selection of case studies, focus groups, and interviews as primary data collection methods. The findings section will present and analyse the empirical insights gleaned from the study, shedding light on the strategies adopted by automotive supply chain stakeholders to enhance resilience. Finally, the conclusion will synthesise key findings, highlight implications for theory and practice, and outline avenues for future research, thereby encapsulating the essence and significance of this investigation.

LITERATURE REVIEW

The New Disruption

The scale and magnitude of the COVID-19 outbreak is catastrophic compared to the other experienced disruptions (e.g. earthquakes in Japan, and Tsunamis in Southeast Asia) (Moosavi and Hosseini, 2021). And the disruption raised by it propagated through enterprises and companies in global supply chains (Guan et al., 2020). Taking the German automotive supply chain as an example, which is dependent on extensive international supply chains, the demand for motor parts and vehicles fell due to the lockdown in China, and reductions in the output of various raw materials constrained upstream production of motor parts in Spain, Italy and the United States (Mazur et al., 2015). Hence, the disruption caused by COVID-19 has negatively affected the upstream and downstream of global supply chain.

Furthermore, the duration of the pandemic is significantly longer from other disruptions. COVID-19 has made enormous long-term supply chain disruptions in the last two years (Søreide et al., 2020). Part of the reason is that the virus itself has evolved to several variants which has increased the difficulty for the medical profession to stop the spread (Sharma et al., 2021). From a supply chain perspective, on the other hand, many supply chains are designed to be efficient by employing lean approaches, for example just-in-time and single-sourcing methods (Hosseini and Ivanov, 2020). However, these lean strategies may not increase the supply chain resilience and help organisations to response quickly to disruptions. Moreover, due to the length of this crisis, companies are likely to suffer for more extended periods. This includes many firms might go bankrupt from the impacts of COVID-19 (Choi, 2020), which will create difficulties in allocating funds and resources to implement recovery strategies. From this disruption, supply chains are generally suffering from resource and funds crises, and difficult to implement recovery strategies (Liu et al., 2020).

In addition, enforcement measures such as lockdown and travel restrictions were suddenly made according to the regional condition of infection (Chowdhury et al., 2020). These measures have significantly struck the global supply chain and brought plenty of uncertainties to the participants. And lockdown losses are propagated through supply-chain networks (Otto et al., 2017). For example, Shanghai suddenly announced lockdown in March 2022 to deal as a pursuing of zero-COVID policy. As a result, multinationals including Apple, Tesla and Amazon, warned of disruption to their supply chains (Hollinger, 2022). These measures which may result in factory shutdown, labour restriction and logistics delay have trapped organisations into unprecedented uncertainty and made it difficult to make decisions to recover.

Therefore, this unprecedented disruption could be defined as New Disruption in terms of magnitude, duration, and uncertainty. For these characteristics of the New Disruption, existing literature has not systematically summarised caused challenges, and has not yet proposed appropriate solutions. And current responses took by industrial practitioners are mainly to solve the short-term problems encountered by the organisation, which lacks the overall vision of the supply chain and long-term progress.

Supply Chain Resilience

Supply chain resilience, a concept increasingly prominent in the literature, embodies the capacity of a supply chain to maintain or rapidly recover its operational performance in the face of disruptions. Ponomarov and Holcomb's seminal work (2009) laid the groundwork by conceptualising resilience as a multifaceted construct encompassing adaptability, flexibility, and the ability to rebound from disruptions. Building upon this foundation, subsequent studies have delved deeper into understanding the antecedents, drivers, and strategies for enhancing resilience. For instance, Carvalho et al. (2012) employed simulation techniques to redesign Portuguese automotive supply chains, revealing vulnerabilities and informing redesign strategies to bolster resilience. Wieland and Wallenburg (2013)highlighted the pivotal role of relational competencies, emphasising trust, collaboration, and information sharing among supply chain partners as critical for resilience enhancement. Brandon-Jones et al. (2014) offered a contingent resource-based perspective, elucidating how strategic resources and capabilities can bolster resilience under diverse environmental conditions.

Moreover, Pettit et al. (2019) provided a retrospective analysis, tracing the evolution of resilience concepts and strategies over time, underscoring the dynamic nature of resilience amidst evolving business landscapes. Collectively, these studies contribute to a nuanced understanding of supply chain resilience, emphasising the need for integrated approaches that leverage organisational capabilities, collaboration, and proactive risk management strategies to enhance resilience in an increasingly volatile and uncertain environment. But the question is, are the theories, principles, and strategies to mitigate supply chain disruptions still valid to tackle the current massive disruptions? Is there something different that supply chain players need to develop to deal with the current disruptions?

For research published since the pandemic outbreak, most authors presented conceptual works, for example 'lean resilience' proposed by Ivanov and Dolgui (2021) where assets deployed to mitigate disruptions are actively used to generate values. A reason for that not much modelling and empirical research has been reported could be the issue is still in the early stage (Pujawan and Bah, 2021). That is to say, although several articles have been published since the start of the COVID-19 pandemic, systematic, methodologically sound, and theoretically grounded research remains scarce.

So, what could be learned from current literature is that suggestions for dealing with the New Disruption are very limited (Sombultawee et al., 2022). Thus, an opportunity exists for further research into the investigation of the New Disruption and development of better strategies for improving supply chain resilience against pandemic risks or other systemic risks that have not yet been anticipated. This research is going to explore new tools, strategies, and approaches to promote resilience for organisations both in the short term and in the long term. And, compared to earlier general and conceptual research on SCR, this research could influence ongoing supply chain decisions and redesigns more specifically. Therefore, another potential contribution of this study lies in bridging the gap between research findings and industrial practice.

METHODOLOGY

The research methodology consisted of two stages. Stage I focuses on identifying supply chain challenges that organisations in the ASC have faced since the outbreak of COVID-19. This stage involves (i) identification of challenges raised by the New Disruption from a comprehensive literature review; (ii) validation of those challenges in the context of the ASC, and supplemental information upon whether there are more challenges specified to the ASC and have not been covered in the literature, based on data collected via the focus group with 9 experts from 3 organisations in the automotive industry. They are a national OEM, a foreign direct investment OEM and an international supplier.

The aim of Stage II is to find effective recovery strategies in terms of those challenges from the New Disruption. In this stage, senior practitioners from suppliers, OEMS and distributors in the ASC are invited to attend semi-structured interviews. This stage includes (i) investigation of recovery strategies that have been applied by participants' organisations to deal with the challenges, and (ii) comparison of those strategies with ones from the literature to generate a group of solutions which tackle the New Disruption effectively for a possible similar situation in the future. Initially 7 interviewees attended stopped when data saturation has achieved i.e. most of the answers from new interviewees are the same, with totally 15 respondents. They are from 3 different supply chains, ranging from tier 2 supplier to distributor.

FINDINGS

First, the data collected by the focus groups identified a range of challenges that ASCs in China encountered in the New Disruption. The challenges impacted ASC in three main areas: production, logistics and procurement, with a total of 19 challenges cited by respondents. Thirteen of these challenges appeared in the previous literature, and the other six were identified as new challenges brought about by the nature of the New Disruption. Problems on material supply and logistics are most frequently mentioned, including very high inventory costs, high logistics costs, lack of logistics capacity, delivery issues, delay, and travel restrictions. Challenges related to uncertainties from both the outbreak and recovery stages are highlighted, such as sudden lockdown, production suspension, material supply shortages, partners limited operations, difficulties in finding new suppliers, and previous experience unapplicable. Moreover, ISM is used to understand the logical relationship between these challenges and the process of their propagation in the supply chain.

Thematic analysis of the interview data identified five themes for coping strategies: looking for temporary resources, resorting to the government, strengthening collaboration, creating more redundancies, and digitalising workflows. The strategies in the first three themes focused on short-term approaches to the outbreak phase of the disruption, while the last two contained long-term strategies. In addition, all strategies were also classified according to the problems they address, in order to better identify the connection between these strategies and the challenges discussed previously. In this way it is convenient to correspond these strategies with the challenges above, find out the relationship between specific challenges and strategies, and provide references for organisations to further improve their risk management capabilities, in case of similar situations in the future.

Also, to fully understand how these strategies could influence the supply chain resilience, Table 1 categorised recovery strategies from another perspective. The two columns indicate whether the strategy is executed from within the organisation or in collaboration with other parts of the supply chain. In this way, the positive impact of these strategies on the supply chain resilience could be directly reflected, so as to echo the thinking of how to improve the resilience of the supply chain in the research aims.

Table 1 Recovery strategies from different levels

Organisational level	Supply chain level
'Snatching' goods from suppliers	Helping SME suppliers to communicate with the local government
Circumventing travel restrictions by cross docking	Freeing up some passes to the supplier
Arranging urgent shipping tasks	Matching supplier capacity
Finding additional shipping routes	Boosting supplier production
Using temporary alternative suppliers	Requirements of disinfecting parts in advance for overseas suppliers
Migrating production to low-risk areas	Asking suppliers to get higher inventory levels
Dynamically adjusting the allocation of scarce parts	Switch some components to VMI
Applying transportation pass	Sharing logistics resources
Applying for limited production permits	Forming a group to exchange information
Obtaining the latest relevant policies and adjust strategies	Expanding new cooperation opportunities
Increasing inventory levels	Making overall provisioning plans
Changing the JIT to an agile strategy	
Increasing the number of suppliers	
Building a pool of suppliers	
Preparing ahead for long-cycle parts	
Changing business modes	

CONCLUSION

Global supply chains have suffered from the New Disruption in the last two years, while the mechanics of it and solutions have not been well researched, especially in the manufacturing sector. This study identified the challenges posed by the New Disruption to the automotive industry, and summarised the characteristics of the new disruption and its impact on the manufacturing industry, by comparing it with previous literature. At the same time, it also explored the coping strategies of the organisation, and discussed the methods to improve SCR from the perspective of the whole supply chain.

Future research could consider whether these strategies are applicable to other regions or industries and try to quantify the specific improvement of these strategies on SCR.

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Analysis of Design Faults in Building Sustainable Refrigerated Warehouses

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INTRODUCTION

Food manufacturers and retailers are building refrigerated warehouses for their cold chains due to rising demand for diversified refrigerated food products. Third-party logistics providers are also expanding refrigerated warehousing service tailored to customers' needs. Although advances in refrigeration and automation technologies provide cold chain operators opportunities to reduce energy-consumption and improve productivity, these advantages could be offset by missteps at the planning stage due to inexperienced team members, construction constraints, or budget compromise. For example, substandard insulation materials could affect energy consumption and sustainability, but total replacement would cause major disruptions. Most studies on cold chain risks focus on operational issues such as thermal loss cause by inefficiencies of receiving and transportation. Better management and employee training are often recommended for risk mitigation (Ackerley *et al*.2010, Ndraha *et al*. 2018, Sugathadasa *et al*. 2021). Design faults are usually root causes of many operational problems. We employ an approach similar to failure mode and effect analysis (FMEA) to investigate critical design risks of refrigerated warehouses that may hinder operations or lead to cold chain breakage. The objectives of this study are two-fold: (1) to identify risk factors in the design stage of refrigerated warehouses for food and produce, and (2) to determine the priority consideration for addressing the risks identified.

LITERATURE REVIEW

Yuen (2017) surveyed the literature to develop several criteria for qualifying temperature controlled warehouse. The location criteria covered disasters and weather, in addition to proximity and accessibility. Natural disasters present great challenges to cold warehouses. Earthquakes may cause structural damage or collapse. After the 2011 earthquake, Nichirei, a major Japanese marine products company, announced losses of US$ 38.6 million due to devastation of factories and distribution centers (Real, 2011). Even minor earthquakes may displace automated material handling equipment that require re-calibration to regain the capability. Such damages can cause significant disruption to business continuity and business losses can be far greater than losses from physical damage (Suppasri *et al*., 2022).

Many regions in East Asia are subject to typhoons that bring heavy rain, flood factories and warehouses, and damage goods and equipment. The roof and exterior walls of the cold storage may be damaged by strong winds. In 2019, Typhoon Lingling slammed into South Korea –ripping off the roof of a distribution center, destroying a third of the building's freezer and ruining $1.3 million in food products. There were also cleanup costs associated with the recovery, which could take weeks (Phipot 2019).

Electrical faults and human errors often cause cold storage fires which pose a threat to life, damage stock, and shut down business operations. In 2020, a massive fire destroyed a newly constructed cold warehouse in South Korea and killed 38 workers. One of the reasons for the fire damage was that the builder did not put incombustible materials between the walls because of cost concerns (Kim, 2020). A cold warehouse in Ohio, USA was completely destroyed by fire in 2016. Knowing that cold storage buildings were dangerous, firefighters could do little more than watch the fire burn itself out (Renner, 2018). Cao (2020) studied the fire prevention of cold warehouses and proposed countermeasures such as air sampling smoke detection, fire-proof walls, and layout design to minimize damages.

Wall, roof, and floor insulation are vital to maintaining energy efficiency and preventing condensation inside a cold storage. The selection of insulation panels is largely governed by the required temperature and building cost. But the insulation material must not only meet the thermal conductivity requirement, it must also be odor-free, impermeable to water vapor, anti-rot and both vermin and fire-resistant. Air-tight and moisture-tight construction also helps to prevent the accumulation of water vapor which condenses to form frost or ice (Chidom 2013).

The design of the refrigeration system is another crucial decision for a cold warehouse from both an economic and environmental viewpoint. Francis *et al*. (2017) suggested that the industry focuses on improving design, installation and maintenance of pipework and valves, at the components that most often develop faults to minimize refrigerant leakage. UN Environment and IIR (2018) recommended that the design of refrigeration systems, refrigerants, and the cold distribution loops used should depend on the required temperatures and the size of the facility.

Other design requirements include a reliable electric system, availability of different temperature-controlled storage, air flow and ventilation, and well-insulated doors (Yuen 2017). Dock doors are one of the major sources of heat gain into a cold storage and need to be designed and maintained with attention to vapor seals and avoidance of conduction paths. Significant reduction in heat loads and improvements in energy efficiency are achieved by using airlocks, rapid roll doors and strip curtains (Fikiin and Markov 2014).

The interior layout has a determinative effect on storage capacity and quality of stored goods. Insufficient unloading space may delay the operation and cause product temperature warmer than desired (Wu and Hsiao 2021). Precooling is the first and one of the most important steps for the preservation of vegetables and fruits. Raut *et al*. (2019) identified thirty criteria for reducing the food losses in fruits and vegetable supply chain. They suggested that the highest weight of criteria is "Efficient precooling and temperature variability-controlling equipment facility". Zhao *et al*. (2018) reported that there were many old cold warehouses in China and the lack of appropriate precooling had caused greater postharvest wastage.

RESEARCH DESIGN

A technical study of cold warehouse design would require gathering sensitive information not easily available. Surveys and expert opinions were often used to study risks in cold chain operations. Risks were then prioritized using quantitative tools (Ackerley *et al*. 2010, Raut *et al*. 2019, Wu and Hsiao 2021, Sugathadasa *et al*. 2021). Thus, we conducted in-depth interviews with six Taiwan experts to develop a framework of design risks of building refrigerated warehouses. We initially identified twenty-five design faults from the literature and news reports and asked experts to review and suggest revisions.

Expert A was the general manager of a temperature-controlled distribution center which stored agricultural products, foods, and electronic products. He warned that inadequate ground insulation could cause cracks and heaving. He emphasized the location of docks should avoid direct sunshine in summer and there should be adequate space for handling inbound and outbound goods. Expert B was the manager of another temperature-controlled distribution center which stored frozen seafood and frozen meals. His concerns included anti-seismic structure, puncture-resistance of insulation panels, backup power system, air-tightness of docks, and pre-cooling room. He also cautioned against using a storage room designed for chilled products to store frozen foods.

Expert C was the general manager of a cold storage construction company. He emphasized proper assembly of insulation panels and the strength of the racks to guard against natural disasters. The design of the piping system has a significant impact on uniform temperature control. Other suggestions include that inadequate electrical installation with subsequent alternations is one of main fire hazards and a poor choice of the location could complicate the task of pest control. Expert D was the general manager of another cold storage construction company. He cautioned that government regulations had only basic requirements on building safety and agreed with the importance of anti-seismic structure and proper assembly of insulation panels. He advocated erosion-resistant design for outdoor equipment and avoidance of west-facing location of the condenser unit. Inadequate air-filtered ventilation could damage food products. He also stressed that aisle layout and width were keys to operational efficiency.

Expert E was the deputy director of a research institute. He had been a strong advocate of establishing standards for cold chain logistics and had helped designing several cold warehouses. He first expressed that the design depends heavily on the business model, then pointed out common design faults such as improper electrical wiring, inadequate roof construction, poor design of the docks, sliding doors, and loading area. Inadequate design of the refrigerated system would increase energy consumption and reduce the service life. Poor drainage design could cause formation of ice and system blockage. He considered keeping the storage area dry the prerequisite for pest control. Expert F was a professor in logistics and had helped developing PAS 1018 (ISO 23412) for refrigerated parcel delivery. He suggested adjustable sealing and dock leveler to accommodate different truck sizes to minimize heat transfer. He also recommended adequate space for unloading and loading area to reduce delays and anti-seismic design for AS/RS to avoid complete shutdown.

The interviews resulted in forty-five risk factors which were classified into nine categories: main structure (A1~A8), insulation(B1~B8), dock design (C1~C4), refrigeration system (D1~D9), piping (E1~E3), electricity (F1~F2), layout (G1~G4), racking (H1~H3), and environmental hygiene (J1~J4), as shown in Table 1. Then we developed a questionnaire based on FMEA and asked eight experts to assess each risk factor for its severity, likelihood and difficulty of recovery.

We defined severity of functional failures caused by a design fault as the amount of damage immediately resulted such as fresh grocery tainted by fire smoke. Probability was defined as the possibility of functional failures due to a design fault during the first half of the design lifespan. The recovery effort was the amount of time required to minimize the failure effect such as replacing equipment or resume at least 80% of the operation. In consideration of the impact of cold chain breakage, we replaced detectability of the nonconformity commonly used in FMEA with recovery effort and considered recovery effort different from severity. We were motivated by the argument that reducing supply chain vulnerability meant reducing the likelihood of a disruption and increasing resilience — the ability to bounce back from a disruption (Sheffi and Rice, 2005).

The rating of severity of failure is 5 if the facility is unable to maintain temperature in the long term and/or more than 20% of the facility has been damaged and 1 if no immediate repair is necessary or no significant effect. The rating of probability of occurrence is 5 if the probability is higher than 80% during the first half of the design lifespan and 1 if the probability is lower than 5%. The rating of recovery effort is 5 if it is almost impossible to recover from failures caused the design fault and 1 if recovery can be expected within hours. Finally, the average ratings across experts are multiplied to obtain risk priority number (RPN) for each design risk, as displayed in the last column of Table 1.

Table 1: Risk Priority Numbers for Design Risks of Cold Warehouses

	Design risk	Failure effect	RPN
A1	Poor anti-seismic structure	Structural damage	53.8
A2		Damage of material handling equipment	47.5
A3	Poor typhoon-proof design	Goods and equipment damage	41.8
A4		Roof and wall panels damage	48.0
A5	Lack of tsunami-resistant design	Structural damage	56.4

A6	No fire wall	Aggravation of fire damage	55.2
A7	Low floor load capacity	Floor cracking	64.2
A8	Low grade concrete	Mold or ice on the wall	50.9
B1	Lack of incombustible material	Aggravation of fire damage	54.0
B2	Low grade insulation materials	Water saturation in insulation	56.7
B3		Cracking of insulation	47.7
B4	Poor floor insulation	Ground buckling	49.9
B5		Floor cracking	41.6
B6	Poor roof insulation	Condensation and dripping	47.6
B7	Improper panel assembly	Temperature fluctuation	47.4
B8		Panel contraction leading to cracks	40.6
C1	Improper dock location	Operations affected by weather	42.4
C2	Substandard dock seals	Airflow and energy loss	27.6
C3	Inadequate dock facility	Low operational efficiency	42.8
C4	Substandard sliding door	Condensation, frost, temperature fluctuation	33.7
D1	Outdated design of refrigerated system	Low efficiency, maintenance problems	47.7
D2	Improper configuration	Energy inefficiency, temperature fluctuation	59.9
D3	Inadequate cooling capacity	Temperature warmer than desired, low energy efficiency.	58.5
D4	Lack of corrosion-proof design	Corrosion of outdoor equipment	38.5
D5		Damaged insulation causing electrical leakage	33.9
D6		Pipe cracks	39.1
D7	Inadequate backup system	Temperature warmer than desired	40.1
D8	Inadequate water supply	System shutdown due to water shortage	30.9
D9	Wrong location of condenser unit	Poor heat exchange, reduced system efficiency	36.5
E1	Inadequate piping layout	Non-uniform temperature distribution.	47.5
E2	Poor drainage design	Water leaking or formation of ice	36.6
E3	Lack of seismic design for piping	Pipe breakage, system shutdown	48.3
F1	Electrical wiring faults	Fire due to overload	55.9
F2	Inadequate allocation of backup power	Refrigerated system not properly functioning	42.6
G1	No pre-cooling room	Condensation, temperature fluctuation	45.1
G2	Improper temperature zoning	Uneven utilization of storage spaces	38.6
G3	Insufficient space for staging and shipping	Low operational efficiency	49.2
G4	Poor layout for staging/ shipping	Traffic collision, low operational efficiency	25.0
H1	Improper rack assembly and installation	Reduced load capacity	35.7
H2	Weak rack strength	Beam bending or collapse	39.9

H3	Poor seismic resistance of racks	Damage to racks, goods falling off	42.6
J1	Lack of prevention of rat infestation.	Food and packaging contamination	25.0
J2	Lack of insect prevention	Food and packaging contamination	21.3
J3	Non-leak-proof roof	Products damages and slippery floor.	34.4
J4	No air-filtration	Food and products tainted by smoke or gas	13.0

DISCUSSION

We limit the discussion to top 12 design risks ranked by RPNs. Table 2 displays average ratings for severity, probability of occurrence, and recovery effort for each top ranked design risk. Numbers in the parentheses are standard deviations among eight experts. Experts mostly agreed on severity and recovery effort, but had different opinions on the probability of occurrence because some incidents were rare and not all experts had firsthand knowledge of those incidents.

Table 2: Top Ranked Design Risks

	Design Risk	Failure Effect	Severity	Probability	Recovery
A7	Low floor load capacity	Floor cracking	4.6 (0.48)	3.1 (1.27)	4.5 (0.71)
D2	Improper design of refrigerated system	Energy inefficiency, temperature fluctuation	4.3 (0.66)	3.4 (0.99)	4.1 (0.78)
D3	Inadequate cooling capacity	Temperature too warm. Low energy efficiency.	4.4 (0.48)	3.5 (1.00)	3.8 (1.09)
B2	Low grade insulation materials	Water saturation in insulation	4.5 (0.71)	2.8 (1.64)	4.5 (0.71)
A5	lack of tsunami-resistant design	Structural damage	4.8 (0.66)	2.4 (1.65)	4.9 (0.33)
F1	Electrical wiring faults	Fire due to overload	4.9 (0.33)	3.0 (1.00)	3.8 (1.20)
A6	No fire wall	Aggravation of fire damage	4.6 (0.48)	3.0 (1.00)	4.0 (1.00)
B1	Lack of incombustible material in insulation	Aggravation of fire damage	4.5 (0.50)	3.0 (1.32)	4.0 (1.00)
A1	Poor anti-seismic structure	Structural damage	4.6 (0.48)	2.6 (1.22)	4.5 (0.71)
A8	Low grade concrete	Mold or ice on the wall	3.9 (0.93)	2.9 (1.05)	4.5 (0.50)
B4	Poor floor insulation	Ground buckling	4.3 (0.83)	2.9 (1.36)	4.0 (0.87)
G3	Insufficient space for staging and shipping	Low operational efficiency	3.6 (0.99)	3.8 (0.97)	3.6 (0.86)

Due to the geographic location of Taiwan, it is no surprise that poor anti-seismic design (A1) and lack of tsunami-resistant design (A5) ranked very high among design risks. Although the probability of occurrence was relatively low, experts agreed that the structural damage could be very severe and recovery effort could be tremendous. An example of risk aversion and improved sustainability is that Nichirei built a large refrigerated warehouse with seismic isolation system after suffering huge loss in the 2011 earthquake.

Fire hazards were a major concern among experts. Electrical wiring faults (F1), no fire wall (A6), and lack of incombustible material in insulation (B1) all received high RPNs. Experts agreed on the high severity of fire damage that might be caused by electrical problems. Cold warehouse should include fire-prevention designs to stop the spread of fire and sav lives and recovery effort. The cold warehouse devastated by fire in Ohio was rebuilt with the latest in fire protection technology, including fire access doors, pull stations at doors, linear heat detection in freezers, and automatic smoke vents (Renner, 2018).

Cold warehouses installed with improperly designed refrigeration systems (D2) could be caused by lack of knowledge or change of business model and would incur high energy cost or high maintenance cost. Cost concerns often lead to insufficient cooling capacity (D3) which results in high energy consumption and air temperature warmer than desired. Recovery via equipment upgrades are expensive but could be the best long term solution.

Insulation is a major expense of building a cold warehouse. A small error in materials selection or workmanship may affect the long term performance. The ground floor needs to support heavy equipment moving palletized goods in cold or freezing temperatures. Low floor load (A7) may cause cracks and damage to ground insulation. Poor ground insulation may cause buckling (B4) and hinder material movement. Low grade insulation materials (B2) may cause insulation in ceiling or walls to become saturated. Low grade concrete (A8) for walls may grow ice or mold. Experts agreed that it would be a difficult task to recover from these failures. Cold chain operators need to work with quality construction companies to ensure minimal maintenance and long term sustainability.

The risk of insufficient loading and unloading space (G3) had the highest probability of occurrence among all risk factors. This could be due to high land costs in Taiwan. Although not a severe risk, limited space may compromise operational efficiency or employee safety. Loading and unloading delays result in product temperature warmer than desired.

CONCLUSION

Designing and building a cold warehouse with high capability is a complex project requiring meticulous planning. The literature is limited on design risks of cold warehouses which could seriously affect product quality and long term operational efficiency. Our research interviewed and surveyed cold chain experts and identified forty-five potential risks in the design phase. We prioritized these design risks based on severity, probability of occurrence, and recovery effort and found disaster-resistance and sustainability received most attention from experts. This study offers a reference for evaluating risk factors that require priority considerations at the planning phase. Cold chain operators in developing regions or seismic zones may benefit from a broad assessment of both the frequency and severity of potential design risks. Subsequent research on this subject could prevent or reduce the occurrence of operational problems and contribute to sustainability of cold chains.

Most interviews and assessments were conducted in 2021, during the peak of the pandemic. Thus, we were unable to call for a group discussion or consult more experts. Another limitation is that the study was conducted in Taiwan, where ambient temperature ranging between 10℃ and 35℃ year round. Cold warehouses in regions where earthquakes are rare or freezing temperatures are common in winter may face other challenges.

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A Framework to Benchmark Material Master Data Management Implementation: Implications on Supply Chain Processes in FLSMIDTH

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INTRODUCTION

Material master data (MMD) comprises the descriptions and attributes of all the materials an organisation procures, produces, and keeps in stock. MMD are kept in a centralised repository, and consist of various data elements, which formally describe the item, including but not limited to, the part number, description, technical specifications, and stock codes (Verdantis, 2010). Oracle (2009) emphasises that master data are critical to support the transactional and analytical operations of a business. Furthermore, and more specific to supply chain management, the use of inconsistent and fragmented material master data creates supply chain inefficiencies and, results in poor market penetration and a slowdown in time-to-market (Oracle, 2009). Partida (2012) described material master data management (MMDM) as the process of standardising and centralising the management of material master data elements, from the creation to the ownership and governance. This is based on naming conventions and predefined processes.

FLSmidth (FLS) is a leading provider of engineering, equipment and service solutions to the global cement and mining industries, employing 12,200 employees in more than 50 offices around the globe (FLS, 2019). These employees are mainly engineers responsible for developing, designing, planning, installing, and servicing equipment, while most of the manufacturing is outsourced to suppliers. The company supplies a range of industrial products and services with its primary goal of delivering sustainable productivity to its customers by increasing output, lowering operating costs and minimizing the environmental impact of its customers. These solutions include product lines and processes such as centrifugation and classification, conveying, crushing, and sizing, emission control, feeding and dosing, filtration, flotation, milling and grinding, mine shaft systems, screening, thickening, and clarifying to customers in cement manufacturing and mining of gold, iron ore, copper, coal, and various other minerals (FLS, 2019). From as early as 1990, through mergers and acquisitions of various new companies, including Pfister, Möller Materials Handling, Vecor, Abon Engineering and Buffalo, the company strengthened the minerals division of the Group and continued to display its character of innovative thinking and a passion for excellence (FLS, 2019). Resulting from the many mergers and acquisitions over the last few years, FLS has many disparate ERP systems, each owning its own set of data. Each company that was bought operated independently under the FLS with its own ERP system hosting its own set of master data in terms of a general ledger, suppliers, customers, and materials. Systems were not integrated with the main ERP hosted by the company head office in Denmark, resulting in the lack of visibility of inventory, poor master data management practices, and extensive effort to consolidate transactional data for effective analysis.

For organisations like FLS to harmonise and streamline data after mergers and acquisitions, there are external service providers (ESPs) of master data management (MDM) to guide this complex undertaking. These MDM ESPs provide operational, tactical, and strategic support to organisations engaging in MDM programs (O'Kane, Judah, Moran & Jain, 2017). The following MDM ESPs in the market of master data management: Gartner, Verdantis, IMA, Oracle, KPMG, and PiLog, amongst others, have all contributed to the literature by publishing articles, whitepapers, and conference papers around the research topic of material master data management. One such MDM ESP, PiLog, was instrumental in creating the framework for ISO 8000, the international data quality standard.

PiLog serves various industries in South Africa, including the mining industry, and provides MDMM services such as data cleaning and classification, data management, master data governance, material criticality analysis, and enterprise asset data acquisition using a master data quality solutions (MDQS) platform that consists of a library with pre-defined data to automate and integrate governance processes in organisations. PiLog's involvement in the mining industry and the similarities between PiLog's customers and FLS in terms of the technical complexity of the material master data, provide a basis to benchmark the status of MMDM implementation in similar organisations like FLS. It is the creation of a framework to assess material master management implementation through the implementation of a cataloguing tool that is of particular importance in the research**.**

APPROACHES TO MMDM IMPLEMENTATION

It is evident that MDM external service providers (ESPs) are needed for MDM implementation. In this section, the aim is to compare the philosophies, practices, and services some of the major MDM ESPs offer to their clients. Many consultants in the field of MMDM have developed an approach to improve material master data records in ERP systems referred to as Extract, Transform, and Load (ETL) (Knapp & Hesibether, 2011:6). Once the data has been extracted from the ERP system, the transformation process takes place in two steps. The first step is meta data development. At this stage, the standard, that will be used to structure the extracted data, needs to be agreed upon. The second step, the data quality improvement process, includes the harmonisation of the data, data cleaning, data enrichment through adding missing attributes, and finally duplicate handling. This is an iterative process that continues until the data are in an acceptable state to be uploaded into the ERP system.

Zwarts (2018) outlines a similar comprehensive MDM solution implementation, involving two main elements. The first entails cleansing and structuring unstructured client data through automated processes until it meets acceptable quality standards. The second involves deploying software to manage master data life cycles, integrating it with business platforms through a business integration process. This is achieved by collaborating with the IT function to design infrastructure meeting these requirements. While not outlined in 10 steps, PiLog's MMDM implementation process aligns with that of IMA Ltd (Facciotti, n.d.).

While most MDM ESPs use automated software to clean master data, this can only be done with human intervention in the form of specialists who will ensure accuracy, consistency, and efficiency (Facciotti, n.d.). Facciotti (n.d.) outlines a 10-step process for MDM implementation. Step 1 establishes a standard operating practice (SOP) defining data format, naming, and abbreviations. Step 2 involves a pre-cleaning process using automated software to structure raw data. Step 3 assigns noun-modifier pairs per item. Steps 4 to 6 define attributes, assign classification codes, and identify duplicates. Step 7 is a quality control review, followed by client input in Step 8. Step 9 involves sending cleaned data to IT for ERP integration, and Step 10 uploads the data into the client's ERP system. This aligns with the typical ETL process described by Knapp and Hesibether (2011:6).

Verdantis collaborates with consulting firms, system integrators, service providers, and technology vendors, offering services in ERP, MDM, and supply chain management initiatives (Verdantis, 2018c). One focus is material MDM solutions for organizational mergers, process improvements, and ERP implementations. The Verdantis Suite, part of The Verdantis Advantage, employs an automated approach to clean and de-duplicate data, emphasizing the importance of maintaining cleanliness through robust data governance processes, including fuzzy logic capability and configured workflows. The methodology, driven by artificial intelligence (AI), aligns with the ETL philosophy, involving data extraction, structuring, and cleaning for ERP upload. Verdantis provides flexibility in classifying data into various standards, such as "UNSPSC, eCl@ss, PIDX, NATO, or a customer's custom schema" (Verdantis, 2018c).

PROBLEM STATEMENT

The problem being investigated in this study is that there is no validated framework for assessing the status of MMDM implementation in existing literature. In addition, the status, or the level of maturity of MMDM implementation in FLS is unknown.

RESEARCH METHODOLOGY AND DESIGN

The research method and design utilized in this study is a qualitative case study. Key informant interviews were conducted to gather qualitative data. Two data collection tools were self-developed following a comprehensive literature review. These were for i) for the PiLog customers and FLS and ii) for PiLog employees. The main themes identified from the literature formed the foundation for designing the interview guides. The population targeted for this study included employees and customers from FLS and PiLog, specifically aiming to:

i.) Determine the status of MMDM implementation in FLS by interviewing FLS employees.

ii.) Validate the MMDM implementation framework and identify best practices for MMDM by engaging with PiLog employees.

iii.) Assess the benefits of MDM ESPs in MMDM service provision through interviews with PiLog customers.

The sampling method employed was purposive sampling, focusing on a target sample of 25 participants. The qualitative interview data were transcribed and coded prior to conducting content analysis, which aimed to identify the key themes emerging from the interviews. Specifically, conceptual analysis was employed to track the recurrence of particular words, themes, or concepts within the interview transcripts. The transcribed interviews were then organized into manageable content categories through coding. Concepts were coded based on their frequency, enabling the researcher to tally the occurrences of each concept within the text. The text was manually coded, and the results were subsequently analysed. This approach was deductive, utilizing existing MMDM theories to deduce the moderating role of PiLog in MMDM implementation within FLS. To ensure validity and reliability, triangulation was used.

RESULTS

A total of 18 participants from FLS were interviewed. From the initial selected sample of 25 FLS employees, 11 participated in the first round of interviews, and through snowballing an additional seven participants were identified and interviewed. From the 18 participants that were interviewed within FLS four were female and 14 were male. The participants included group category managers, vice presidents of product line management, managers within group strategic procurement, managers of business tools and processes, as well as project managers from different regions and industries. Only one senior executive from PiLog was interviewed. The PiLog participant is globally responsible for the implementation of MMDM strategies for PiLog customers. The participant's knowledge and expertise around MMDM implementations represents the norms and practices of PiLog sufficiently.

Framework for assessing the status of MMDM implementation.

This section presents the framework of assessing the status of implementation of MMDM in an organisation. The MDM model described in the literature review comprises four elements: governance, process, content, and systems as shown in Figure 2. The data collected from the PiLog interview participant were used to substantiate the validity of these elements.

1. **Systems** The basis of the MDM / MMDM model is a system and landscape or infrastructure to host the master data with its rules and interfaces. This first element needs to be in place for MMDM implementation in any organisation. Technology in the form of a business system to support master data business processes is a major element when implementing a governance model.
2. **Content** The second building block to a full MMDM implementation is content. Content refers to the structure of material master data objects which is referred to as codification according to specific codification standards. It is important to define specific tools and classification standards that are used in the industry for effective codification, to improve the quality of master data.

   Naming conventions, naming syntax and semantics are fundamental to codification. The purpose of codification is to "facilitate a common item of supply language", which will eliminate duplication by examining the item, comparing it to other similar items and then allocating or creating a unique item code to create one version of the truth.

   Proper codification is achieved through:
   - Master data record manager (MDRM) – software application that is used to manage master data which includes modules for various master data sets.
   - Structured text generation –software application with fewer rules and governance requirements than the MDRM but is more goal specific. It is a quick and easy solution that can be used to eliminate free text purchases while the MDRM is being implemented by guiding the customer to create semi-structured descriptions.
   - Technical dictionary – is a dictionary with templates used in the master data process. It includes standard units of measure, multi-lingual facets, standard abbreviations and many more.
   - Standardisation of parts descriptions as well as units of measure, such as centimetres or kilograms, are crucial for quality content. The governance model implemented by one of the PiLog customers had pre-defined standards as a focus area for the model to be successfully implemented.
3. **Processes** Various business processes need to be considered when implementing a MMDM solution: standardisation and centralisation of MMDM, data cleaning, codification, quality assurance, workflows, functional integration, and governance. Iterative processes are essential for the improvement of master data quality. Each process needs to be properly defined for MMDM to be an efficient business function.

   Once the data have been cleaned, they are contained and maintained in terms of the quality. Parallel to the first step, the systems around master data management are addressed by conducting software configuration workshops to understand the customers' organisational structure, existing governance structures, existing systems, and IT infrastructure, and to identify the various stakeholders in the business environment.

   This is followed by defining the level of configuration that is needed for the software integration of all systems. Once the software is developed, it is tested in a development environment at the client as a user acceptance test (UAT). Parallel to the UAT and following on from the software configuration workshop, there will be two streams: one looking at the systems integration software, while the other involves infrastructure configuration. The most challenging aspect of implementing MMDM solutions at customers is to obtain access to their servers. Once the system integration phase is done, testing, quality assurance, onsite user training, sign off and final implementation follow. Some companies only require the data cleaning tool and not the maintenance tool.

4. **Functional Integration and Governance.** Governance is the overarching and strategic level of the MDM model, which also includes the MDM policy and strategy with guiding principles to ensure good corporate governance. Governance is fundamental to MMDM and forms part of the definition of MMDM. Governance is one of the four MDM elements needed to employ a well-functioning MMDM strategy. Governance can only be implemented if there is a clear policy with a set of rules to ensure compliance.

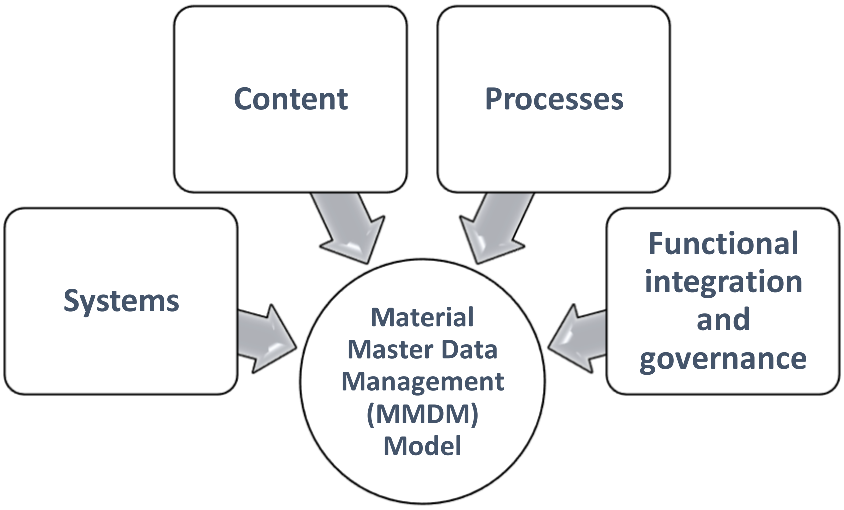

Figure 1: Framework for assessing the status of MMDM implementation.

Status of MMDM implementation at FLS

6.2.1 Systems

The participants understood MMDM as a system and could name some systems that exist within FLS which were perceived to be MMDM. This tacitly imply that MMDM is synonym with a system and that some early stages of MMDM implementation are in place in FLS as shown in some of the participants' response below:

- *"We have something, but it is messy and not working. Too many different ERP systems on SAP, anyone could create an item for use…. created very differently by different users." (P11)*

"SIEVO is used as a tool to consolidate transactional data from all ERPs so that group category managers (GCMs) can analyse data across entities." (P0)

The systems presented as solutions to MMDM are however not in alignment with the requirements from the MDM model. One of the participants (P0) confirmed that either SIEVO or Kairos are used for MMDM, however, these are analytical systems that are used in procurement to analyse transactional data and conduct commodity market analysis. Similarly, three participants were under the impression that Atlas PSA, Oracle, or the ERP systems in the regions are used as tools to codify material master data. Six participants from different backgrounds, but in senior positions were not aware of any MMDM systems in place in FLS. These participants are aware of the business systems within FLS and understand MMDM tools from previous roles occupied.

Content

Standardisation within a MMDM context means that items with the same physical characteristics are assigned the same item code and description. One of the interview questions to FLS to contextualise" content" was whether FLS uses one unique stock item across all business units within the organisation. The majority (16) of responses to this question were negative. However, there seems to be differences in the extent of use of standardized codes between industries, regions where each participant is positioned. In the cement sector, there is one ERP system namely, Atlas PSA, is used across all regions with one item number referred to as a Pd.B. number for a unique item. For mining there are some offices that have unique item numbers for the regions, but this is not shared across all business units. Some of the product manufacturing entities also have one ERP across all regions with one unique item number across all entities. There are thus quite disparate practices around the coding of item numbers. The following responses from participants confirm that there is awareness and a need for standardisation within:

"We started the process. It is a huge task. But we need to focus on standardising our products." (P3)

- *"Around 9-10 years ago FLS started a process consolidating its ERP systems with Oracle (Helios). Lots of time and money was spent on discussions, but no one action was pushed to conclusion." (P6)*

Processes

The participants from the first round of interviews with FLS confirmed that there are currently no defined processes to manage MMDM. However, the business acknowledged the importance of the process as there have been attempts in the past through a project called Helios, to consolidate ERP systems into one platform.

Governance

In terms of existing policy and procedures around MMDM in FLS, only two of the participants confirmed that there is a policy and some procedures around MMDM within FLS, but they were not able to provide evidence in the form of documentation. Only one participant was positive that there is no policy or procedure. The remainder of the participants had no knowledge about the existence of such documents in FLS. At the time of interviewing the MDM team these practices were not yet in place. It is thus fair to deduce that the state of implementation of MMDM in FLS is in its early stages as governance setting in MMDM and lacks the quality assurance and reporting part of governance.

DISCUSSION

This study developed and validated a framework to assess the status of the implementation of MMDM. The paper adopted and integrated the approaches of Knapp and Hesibether (2011:6); Zwarts (2018) and Verdantis, (2018c). The framework was validated through key informant interview with a PiLog employee responsible for MMDM implementation. The study subsequently assessed the status of the implementation of MMDM at FLS. The study found that the status of MMDM within FLS was below the benchmark although the company embarked on the initial implementation of systems through which standardisation, asset management, and engineered services can be synchronised. The generation of the material master data is not in line with the best practices within this field. This has some negative implications for the supply chain processes, especially in terms of inventory management, contract compliance, strategic sourcing strategies, and spend analysis for reporting purposes. These findings support prior studies stressing the significance of precise and standardized material master data in streamlining supply chain activities (Ng et al., 2017).

The emphasis on content standardization, including concepts like Master Data Record Manager (MDRM) and Technical Dictionary, mirrors the recognized need for standardized data models to enhance supply chain efficiency (Gualo et al., 2021). The governance challenges identified in MMDM implementation at FLS align with the literature emphasizing the importance of governance models in sustaining MMDM processes (Jones, 2016).

The findings underscore PiLog's crucial moderating role in MMDM implementation at FLS. The implementation of a comprehensive suite of MMDM products and the emphasis on standardization, including a technical dictionary, align with existing research advocating for standardized data quality frameworks (ISO 8000) to optimize material master data (Gualo et al., 2021). PiLog's involvement in addressing challenges faced by FLS, such as convincing customers and obtaining access to infrastructure, highlights the supportive role of ESPs in overcoming implementation barriers (O'Kane et al., 2017). The governance model implemented by PiLog, focusing on organizational structure, business processes, and systems, reflects the recognized importance of governance in sustaining MMDM initiatives (Jones, 2016).

As this was a qualitative study, the research is subjective and could have a risk of the researcher being biased. The fact that only one participant, a senior executive from PiLog, participated in an online interview limited the input around best practices by third-party providers of MMDM services. The best practices were established from the practices of one third-party provider of MMDM services. It could be that conducting similar research across a wide range of third-party service providers could derive a different benchmark.

There is potential for future research around the topic of MMDM, especially with the new technological developments around digitalization, blockchain, big data, data lakes, Industry 4.0, and the Internet of Things. It is of utmost importance for the body of knowledge to understand how these new concepts will impact the structured approaches of coding material master data in the future.

CONCLUSION

It is evident from the above thematic analysis that the status of MMDM implementation in FLS is not fully aligned with the best practices being implemented by third-party service providers of MMDM. The importance of systems in general, item master data creation, business processes around MMDM and governance are in the early stages of adoption in various strategic business initiatives, but MMDM as a strategic function has not yet been realized. While this case study, offers in-depth insights and detailed contextual analysis, of MMDM implementation in FLS and among PiLog customers, it may lack generalizability due to its focus on these cases, making it difficult to apply findings broadly.

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Globalisation of Supply Chains

Open-source ERP System Selection: the Perspective of Internationalizing SMEs

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INTRODUCTION

ERP implementation is risky and expensive (Kilic et al., 2015), and ERP system selection is time-consuming (Wei and Wang, 2004; Ziaee et al., 2006; Kilic et al., 2015). Well-known ERP systems (e.g., SAP and Microsoft Dynamic NAV) are complex, resource-demanding, and inflexible, but open-source ERP systems offer an alternative. Open-source means the code is available and modifiable by everyone or by a community that one can join through a subscription or license. Despite reliability and security doubts (ZDNet.de, 2012), open-source ERP systems shoulder a stable position in the ERP market.

Further research on ERP in small and medium-sized enterprises (SMEs) is relevant (Huang and Yasuda, 2016). Prior research has focused on ERP selection processes in midsize and large organizations (Bernroider, 2001). Advanced approaches for ERP selection and implementation poorly fit SMEs' needs and capabilities (Badewi, 2018). E.g., ERP systems seldom fit make-to-order companies (Aslan et al., 2012), such as many SMEs. There is a need to distill manufacturing SME ERP requirements (Johansson and Sudzina, 2008) and provide an overview of available systems while illustrating an adaptable selection process to follow. SMEs have fewer resources than large companies and follow simpler, more flexible processes (Zach et al., 2014). Here, open-source systems can be relevant as they have functionality similar to regular systems, user communities, and a growing number of service providers that help develop, implement, and maintain the systems.

This paper identifies and shortlists open-source ERP systems suitable for manufacturing SMEs and compares them based on user requirement specifications. The paper develops recommendations for ERP system selection and implementation. In other words, the paper explores what ERP system user requirements exist in manufacturing SMEs, what open-source ERP systems best fit these requirements, and what key critical success factors are. The paper structure entails a literature review, methods, the case, analysis, discussion, conclusions, limitations, and future research.

ERP FRAMEWORK

ERP system selection considers pre-implementation and most of the implementation process (Ehie and Madsen, 2005; Jagoda and Samaranayake, 2017; Motwani et al., 2005). This paper combines existing ERP selection methods with perspectives from operations management (Slack et al., 2016) and operations strategy (Slack and Lewis, 2015) to devise an ERP selection approach for manufacturing SMEs. Advanced as well as simple approaches are available in the literature. However, this paper focuses on the more straightforward approaches as these are more feasible for SMEs.

Process mapping, order qualifier screening, and order winner evaluation

More straightforward methods of selecting an ERP system are relevant for SMEs. Ehie and Madsen (2005) suggest using flowcharts and blueprints. Pitic et al. (2014) suggest a minimum requirement evaluation ranking criteria from zero to three. The final score is obtained by multiplying the vendor and internal team scores. Herzog (2006) uses feature-based analysis to evaluate five criteria groups using different signs, e.g., N/A – not available, + - average, etc. The feature-based approach allows evaluation at any required level of detail (Jadhav and Sonar, 2009). The reviewed articles provide vendor, system, and cost-related criteria further elaborated on below.

To navigate these multitudes of criteria, it is relevant to:

1) map the relevant processes (Slack et al., 2016) of the company to establish what is essential,
2) define order qualifiers (main requirements) and order winners (additional requirements),
3) screen systems using order qualifiers,
4) select among the remaining systems using order winner evaluation.

An order qualifier is a characteristic of a product or service required by a customer. An order winner is a characteristic that likely will win the bid or customer's purchase. Over time, previous order qualifiers will likely become order qualifiers (Slack and Lewis, 2015). Order qualifiers can screen systems away that miss important base functionality or requirements to allow more effort into evaluating the order-winning criteria among only a subset of possible systems, thus saving time and resources in the selection process.

Criteria and critical success factors
The literature outlines various criteria, including vendor-related criteria (Méxas et al., 2012), Systems-related criteria, Functional criteria, Cost-related criteria, and critical success factors.

METHODOLOGY

This paper applies the case study approach (Yin, 2009), which is relevant to investigating "how things work" (Stake, 2010) and to gaining knowledge while using theories and tools in practice (Flyvbjerg, 2011). The focus is on the applicability of open-source ERP systems to the case company conditions, including implementation issues. Case selection criteria included that the company should be a successful international manufacturing SME in selecting an ERP system willing to provide good access and collaborate closely with the research team. Data collection entailed secondary sources, interviews, workshops, demo showcases, and questionnaires. These methods contain qualitative and quantitative elements such as the number of users, price, and so forth, later used for comparison. 20-60-minute weekly meetings with case company senior management took place for four months to clarify questions while gathering and analyzing data. Each research process step included review and documentation, e.g., reasons to eliminate specific systems to avoid undue senior management influence. Business process mapping clarified the case company processes, followed by a current situation workshop providing more detail. A showcase of the current system Asana generated data for validation in following meetings and demo showcases. Meetings and interviews with the case company formed the case company user requirements. Concerning Quality control and Customer Relationship Management (CRM) module requirements, Sheldon Needle's questionnaire (Guides, 2018) served as inspiration. The research included websites, forums, and communities to gather information about ERP systems. Service providers should be EU-present, active, reliable, and have expertise relevant to international manufacturing SMEs. Some systems specify their service providers or recommendations for them on web pages, e.g., ERPNext, VIENNA Advantage, Tryton, and Odoo. Apache Ofbiz has a list of service providers on wikipedia.org.
Questionnaires provided further information before meeting service providers. A meeting agenda, requirements explanations, and a short introduction to the case company shared with participants ensured good preparation. Seven demo showcases with each service provider served to identify if the systems and user interfaces fit the main user requirements. Each demo showcase also involved representatives from senior management and the service provider and was concluded with a demonstration of ERP system features with actions and, transactions and discussions related to the questionnaires. The research team triangulated data from the case company concerning different systems with information from other sources, including relevant secondary data. The research team also shared notes, transcriptions, findings, and results with respondents for feedback.

THE CASE

The case is a Danish SME with production in Italy and global sales. The company needs an ERP system to reinforce high-standard management execution processes and grow while adopting new processes and market requirements. Popular ERP systems are too complicated, and limited resources preclude adopting them in the company.

Case situation

The research included business process mapping of the company's sales and manufacturing processes as input to the user requirement specifications. Currently, the company uses the open-source software Asana concerning, for instance, Customer Relationship Management. However, the system is elementary and requires many manual transactions. The cloud enables sharing information, but uploading files at every change consumes much time, and the different files and spreadsheets make it hard to follow processes. Manual inventory tracking using a spreadsheet causes additional unnecessary mistakes and missing items. Asana stocks uploaded documents regarding issues concerning unqualified goods.

ANALYSIS

This analysis screens and compares relevant ERP systems based on a start sample of 59 different systems identified in articles, books, and websites. The order qualifier screening eliminates systems if it is no longer active, if it is premature (released less than five years ago), if not intended for manufacturing (e.g., for education or retail), and if the system is for specific countries. Subsequently, systems designed for light manufacturing only are also eliminated. As a consequence, nine ERP systems remain.

The lack of service providers within Europe eliminates webERP and xTuple since support during the case company's working hours is crucial. Moreover, different time zones can create additional support and maintenance costs. Focusing less on manufacturing and more on e-commerce necessitates further development and eliminates Apache OfBiz. The research process eliminated FrontAccounting after an in-depth analysis of the system, capabilities, and focus areas revealed that although FrontAccounting supports a manufacturing module's main functionalities, the system focuses on accounting and finance. Concerning Odoo, the community edition does not support manufacturing, and without a hosting option, the commercial version can have manufacturing and invoice modules free of extra charge. Concerning PostBoks ERP by xTuple community version is Free of charge when used by up to 4 users.

ERPNext, iDempiere, Odoo, Tryton, and VIENNA Advantage generally have BOM, Traceability, Multisite functionality, and integrated barcode scanning. However, in iDempiere, barcode scanning and generation are not default features. Tryton has lot number traceability, but serial number traceability is in the testing phase. Concerning Odoo, a finance module is required to enable multi-currency functionality.

In terms of additional requirements, most tutorials are on www.youtube.com. The only exceptions are iDempiere and Tryton. iDempiere's learning tutorials are accessible on a specialized website. Meanwhile, no tutorials exist for Tryton.

iDempiere's and Triton's Quality modules require a Plug-in called libero manufacturing, and the web interface enables a mobile version.

Total Cost of Ownership

The total Cost of Ownership (TCO) calculation compares the financial aspects of some open-source system alternatives (**Error! Reference source not found.**). Time spent by managers and time spent by employees for training is assumed to be the same for all options. Installation and configuration cost estimations include required resources and other related aspects. The assumption is that the case company entirely relies on the service provider to implement and train employees due to limited resources within the company. The Product price calculation for Odoo includes the same modules available in other systems, except accounting. Vienna Advantage perpetual license cost depends on the number of users. Therefore, every time a new user is added, the case company needs to pay the one-time fee. The installation and configuration price calculation considers the time necessary for business analysis (2 days), system configuration (5 days), and going-live support (2 days), calculating seven working hours per day and no additional expenses for travel, accommodation, and so on. The hourly fee for each service provider was the same as indicated for the training service. Support and maintenance cost assumes 30 support hours per year, where the hourly fee is the same as indicated for training. The price for barcode scanners was based on service provider recommendations and included the average price between the cheap (30EUR) and expensive barcode scanner alternatives (400EUR). At the moment, the case company has around ten production employees. Thus during the first year, only a few barcode scanners should be purchased while adding new ones each year due to company expansion and more employees. The hosting price for the on-site installation calculation included the required amount of data and using the average ERP hosting price indicated in www.bitnami.com. The initial communication with service providers did not provide the hosting price for Odoo and Tryton. Therefore, this price was based on the average user price per month and calculated using information based on Vienna Advantage and iDempiere prices. The assumption is that the case company will have 15 users during the first two years and then 20 users during the third and fourth years, and 25 during the fifth year. An estimation suggests that training would take no more than four days. Lastly, development cost was calculated based on the demo showcases, assuming that Tryton would need at least five days of development to add features of quality and CRM modules, while iDempiere would require three days and ERPNext would require one day. Odoo and Vienna Advantage do not require additional development. However, the default Odoo system does not support the barcode-generating app as required. Hence, the app price calculation concerns the product price for one year.

Concerning TCO for the alternatives for each ERP system, the lowest TCO is purchasing the ERPNext online version, followed by ERPNext on-site installation supported by ERPNext in India and the iDempiere on-site installation. The biggest TCO is for the Odoo alternative hosted by the service provider. It is because the company needs to pay for the product and the support and hosting by VKDATA. Another expensive alternative is the hosted iDempiere version from Cloudempiere, followed by the Tryon solution hosted by virtualthings and the Vienna Advantage cloud solution.

In terms of TCO for each year, the cost for most systems goes down in the second year, rising a bit during the fourth year due to the purchase of additional barcode scanners.

Open-source ERP systems evolve quite fast. Five candidate systems have existed in the market for more than five years that have features similar to the usual popular ERP systems like Microsoft Dynamics or SAP. Five potential ERP systems were identified based on the case company user requirements: ERPNext, Odoo, iDempiere, Tryton, and Vienna Advantage. Most of the systems from the list require no product payment or license purchase (except Odoo and Vienna Advantage). However, they require additional configuration or even further development to some extent. Therefore, financial investments are required, yet these are smaller than when buying Microsoft Dynamics or SAP. Open-source systems get support from service providers and have multiple hosting alternatives, which allows the company to choose one or several service providers for different aspects and freely migrate from a self-hosted solution to a hosting service by a service provider and vice versa. iDempiere has only some service providers, which are crucial for the system implementation in the case company due to the complicated system interface. Choosing iDempiere might entail the risk without the possibility of changing service providers since the case company does not have the resources to run the system itself.

However, Tryton did not meet additional functional user requirements because the system does not support CRM and Quality Control modules. In Tryton, these features necessitate further development on request requiring further investment. Odoo was initially very attractive because of its module-based approach. However, a drawback is that additional modules, like accounting, are needed to satisfy the multi-currency requirement. Vienna Advantage proved sufficient regarding the system's features and vendor support. However, the price is higher due to the license fee. Finally, ERPNext proved most suitable for the case company because it meets all main and additional requirements and has a broad network of individual consultants and service providers.

DISCUSSION

ERP system selection is an improvement opportunity not reflected nor sufficiently harnessed in the existing approaches in the literature. Existing ERP system selection approaches excessively use decision-making methods only while lacking theoretical elements from relevant perspectives embedded in operations management and operations strategy. Including business process mapping as input to feature-based requirements ensures a better ERP system fit with the organization. Dividing feature-based analysis into two steps comprising main requirements/order qualifiers and additional requirements/order winners enables requirements prioritization while keeping the selection process simple.

ERP selection table

The ERP selection criteria table (Table 2) is a systematic framework that provides an overview while assessing user requirements customized for open-source ERP systems. The reviewed literature and insights gained from the case company informs the ERP selection table (Table 2). It entails main selection criteria in three major categories: Vendor, ERP system, and Cost, where capitalized words resonate in particular with the empirical findings and the case main selection criteria.

Vendor-related criteria	
The vendor is known for its work with companies of similar size from the same industry. EXPERIENCE IN SIMILAR INDUSTRY	Reputation
The duration of vendor activities and stability of the company. LONG TERM VIABILITY.	
Type of tutorials, manuals, and availability. TRAINING SERVICE	Service/support
The time it takes to get support. RESPONSE TIME	
Possibility to try out the software before purchase. DEMO/ TRIAL OF THE SYSTEM EXISTS	
Possibility to get support from external consultants. EXTERNAL CONSULTANTS EXIST	
System-related criteria	
Hosting solution, type of database if self-hosting is the option	SYSTEM INFRASTRUCTURE
Modules: manufacturing, warehouse management, sales, accounting, HR, etc.	FUNCTIONAL
Globalization, interface language, currency, etc.	
NUMBER OF WORKSTATIONS, the maximum number of users supported	Nonfunctional
RELIABILITY, security, and security policies supported by the software	
RELIABILITY, recoverability, capability to support data backup and recovery feature	
RELIABILITY, robustness, ability to tolerate interference and work without crashing	
RELIABILITY, maturity, the maturity of the system, and history of recent release	
Portability, PLATFORM VARIETY, the capability of the package to run on a wide variety of computer platforms	
Portability, INTEROPERABILITY, ability to export data in a commonly applied format	
Cost-related criteria	
Cost of supporting and maintaining the software (updates, troubleshooting, helpline, etc.)	SUPPORT AND MAINTENANCE
Cost of additional hardware, e.g., scanning devices, computers	COST OF HARDWARE
Cost of training and training material	TRAINING
Price of the complete product with all modules and necessary features	PRODUCT PRICE
Cost of product development	DEVELOPMENT
Cost of on-site installation or hosting program in the cloud	HOSTING
Cost of business analysis, setting up a system, and going live support	IMPLEMENTATION AND CONFIGURATION

Table 2: ERP selection table (order winners) (Capital letters emphasize empirical findings)

Items included in Table 2 concern order winners when selecting an open-source ERP system. Companies using the framework can include other company-specific order qualifiers (as done in the analysis) or order winners as relevant.
A smaller fraction of system-related (technical) criteria is included in Table 2 relative to vendor- and Cost-related criteria.
This smaller fraction suggests that increasingly system-related criteria are merely order qualifiers, whereas order winners are related to vendor service and cost. One can interpret this phenomenon as a change of order winners and qualifiers over time in line with (Slack et al., 2016). From an extended product life cycle perspective, including considering the included ERP systems, this suggests that open-source ERP systems are maturing since different systems can technically perform the same functions and adaptability, whereas vendor-(service)-related and cost-criteria set apart different systems.

CONCLUSION

This paper has combined existing ERP selection methods with perspectives from operations management and operations strategy to devise a selection approach for manufacturing SMEs, including four steps: 1) map the relevant processes of the company to establish what is important, 2) define order qualifiers and order winners, 3) screen systems using order qualifiers 4) select among remaining systems using order winner evaluation. This paper reviewed the ERP evaluation and selection literature from the perspective of manufacturing SMEs, developed user requirement specifications for the case company, synthesized ERP evaluation and selection criteria as illustrated in the ERP Selection Table, and shortlisted and compared (including TCO) open-source ERP systems suitable for manufacturing SMEs. Based on the literature review and data analysis, the open-source ERP selection table helps identify the vendor, system, and cost-related requirements, which are classified into main and additional requirements. The literature review revealed several critical success factors for ERP implementation. Among the most mentioned CSFs are adequately defined project goals and objectives, vendor support and consultants, top management support and team structure, interdepartmental communication and cooperation, and project management. Several open-source ERP systems meet the main requirements. Among them is ERPNext, iDempiere, Odoo, Tryton, and Vienna Advantage. iDempiere has fewer service providers than other systems, and Tryton does not meet the additional functional requirements of the available CRM and quality modules. All mentioned systems have several hosting alternatives and differ concerning the total cost of ownership. Open-source ERP systems seem to mature from a product life cycle perspective, given that order-winning criteria increasingly shift from (technical) system-related criteria to the vendor-(service)-and cost-related criteria.

Limitations and Future Research

The selection made by the case company is biased by their specific needs and preferences. Hence, their choice does not lend itself to general statements about the best system. The study included one case only, whereas further research could investigate other and more SME cases and test the relevance of the ERP Selection Table in such contexts. In terms of further refining Table 2, one could consider including relative weights of importance to the items in Table 2, possibly considering industry or similar elements.

This paper focuses on the early stages of open-source ERP selection and implementation. The paper includes initial assessments of the ERP systems. Future research could compare the final systems using more advanced MCDM reviewed in the literature, such as AHP or others. However, this should consider the needs, limited capabilities, and resources available in SMEs, or such research will likely have little managerial relevance. Future research could expand the TCO investigation used in this paper to include internal and external transaction costs in a lifetime perspective on ERP systems, comparing the benefits and potential drawbacks they provide for their host companies and supply chains. Such research could include focusing on the post-implementation phase, ERP impact on the company (Jagoda and Samaranayake, 2017; Parhizkar and Comuzzi, 2017), and ERP success (Motwani et al., 2005). The post-implementation is usually where the main problems and biggest challenges occur. Further issues concerning adaptability and customizatization also deserve further scrutiny in future research.

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Logistics Connectivity

The ongoing Transformation of Urban Logistics: Implications of The Battle Over Lead Times

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ABSTRACT
Over the past few years, warehousing facilities in both the United States and Europe have once again been in the heart of cities in the form of micro-fulfillment centers (as mini hubs), after having been deported dozens of kilometers away for decades. This evolution is due to the desire of many e-tailers to deliver as quickly as possible to consumers who have ordered products online. Various cases, including that of Amazon, show that the same-day delivery battle is becoming a key element in the strategy pursued by e-tailers. To win this battle, it is essential to set up warehousing facilities as close as possible to consumers. Over the next few years, this will lead to a profound transformation in urban planning and city management. This essay invites practitioners to take account of a notable change in supply chain management, especially regarding the mandatory implementation of a vast network of micro-fulfillment centers.

INTRODUCTION

As e-commerce continues to grow, consumer expectations are evolving, giving rise to a new era in delivery management. When consumers place an order on a website, the excitement of receiving the long-awaited product is now accompanied by a growing anticipation of its ultra-fast delivery, sometimes in just a few hours, and strict adherence to the marketing promise has a major impact on their post-purchase assessment (Ahmed *et al.*, 2024). This explains why the most powerful e-tailers compete to offer ever-shorter delivery times, sometimes even including same-day delivery. This extreme speed brings with it major logistical challenges (Voccia *et al.*, 2019), as e-tailers must solve complex issues such as stock management, order processing and optimizing delivery routes. While ultra-fast deliveries after an online order bring an unprecedented level of convenience, redefining the shopping experience, they also require rethinking several stages of the supply chain, and more particularly the last mile management, which many studies have highlighted as crucial to the success or failure of e-tailers.

A new model is thus emerging, that of "distributed logistics" in the heart of Western cities, breaking away from an old model based on the consolidation of flows in mega-warehouses located far from urban areas after a logistics sprawl process. The reason for this major disruption lies in a *battle over lead times* that is already very prominent in the United States but could soon be raging in Europe. Weak signals confirm that the ability of e-tailers to deliver in a matter of minutes to consumers obsessed with "everything, right away" is becoming a source of sustainable competitive advantage, even if these consumers are not always willing to pay a significant premium for the service (Lasisi *et al.*, 2016). However, this advantage can only be realized if particularly efficient local logistics, or "proximity logistics," are put in place, as shown by the example of Amazon in the United States, with the rapid multiplication of urban mini hubs.

The weak signals mentioned above raise a key research question for logistics management and marketing management: *how do the new expectations of a growing number of consumers in terms of the near-instant availability of products call into question old frameworks based on the logistics sprawl process?* This near-instant availability is a direct result of digital nomadism, which is widely studied in management science, for example in tourist accommodation facilities or global labor mobility, but which is not really linked to the current transformation of supply chains, particularly in the last mile management. The aim here is to suggest that there is a research gap that can be filled by further works into the impact of consumer behavior on the reorganization of warehousing facilities. Same-day delivery is the most remarkable expression of consumer requirement for near-instant availability, and despite its importance, it is still under-investigated from a managerial and societal perspective.

To address this issue, the paper, in the form of an essay, is organized as follows. The first section briefly reviews the history of "logistical cathedrals" built far from cities to facilitate flow consolidation, by emptying urban space of physical infrastructures. The second section underlines the fact that e-tailers' battle over lead times is forcing us to rethink the old logistical model, by setting up micro-fulfillment centers in the heart of cities; however, it is impossible to understand this development without referring to consumers' digital nomadism. The third section shows that a "proximity logistics" is enabling the spread of same-day delivery, under pressure from consumers demanding deliveries just a few hours, or even minutes, after placing an online order. Finally, the fourth section introduces a discussion on the future of same-day delivery, highlighting the paradoxical injunctions to which consumers are subject. The approach adopted is exploratory in nature, with the aim of underlying the central nature of the interaction between logistics management and marketing management to understand the progressive transformation of contemporary supply chains.[*]

LOGISTICS SPRAWL REVISITED

For almost 50 years, the dominant logistical approach has been that of massification, with the idea that it is essential for companies to "see" bigger and bigger to achieve a high level of economies of scale and thus reduce the unit costs of transporting their products, with a major impact on the explosion in land requirements (McKinnon, 2009). With the seminal work of Porter (1980) four decades ago, it is no secret that this is one of the major options for pursuing a low-price policy based on a strategy of cost leadership. Large food and non-food retailers are no exception to this trend. For evidence of this, we need only look at the evolution in the size of their warehouses stocking FMCG before delivery to stores, with the multiplication of mega-distribution centers from the 2000s onwards. Moreover, there is a social justice issue here, as the location of mega-distribution centers is often decided in areas where disadvantaged minorities live, particularly in the United States (Yuan, 2018).

While in the 1980s, the idea of gigantic "logistical cathedrals" was evoked for 20,000 m^2 structures, today it is a commonplace standard, as warehouses well more than 100,000 m^2 proliferate. Unsurprisingly, in the world of large-scale retailing, the United States is home to the world's largest warehouses: 140,000 m^2 for Walmart in Arizona, 185,000 m^2 for Target in Georgia, 260,000 m^2 for Nike in Tennessee... and even 335,000 m^2 for Amazon, again in Tennessee. France is far from being left behind, even if the country's geographical scale justifies smaller warehouses: in the Paris region, Amazon and Conforama (home furnishings) have a 145,000 m^2 warehouse for the former, and 180,000 m^2 for the latter, which is no mean feat. Despite the differences in the size of these "logistical cathedrals," according to the different product categories handled, what they have in common is that they enable a consolidation of flows on a scale never achieved before.

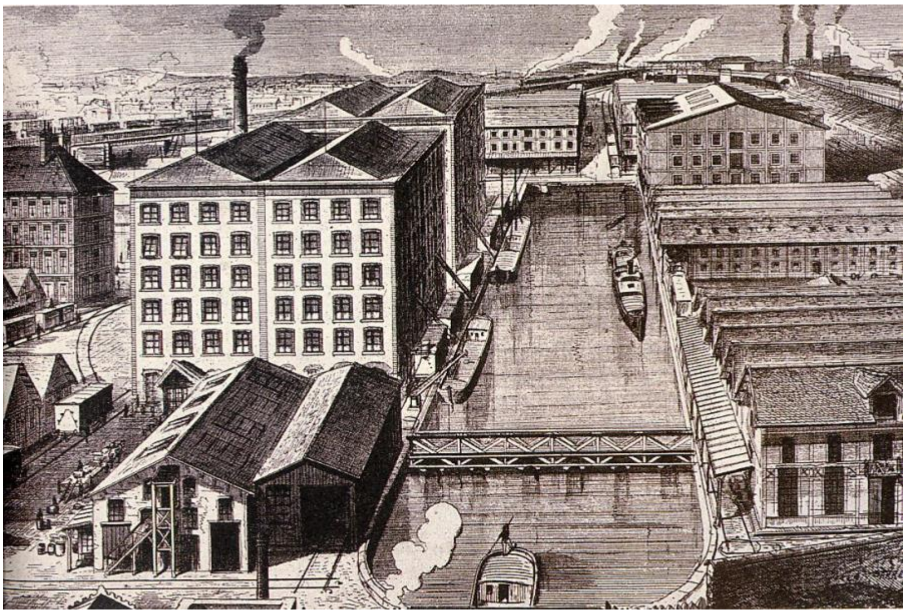
One visible consequence of consolidation in terms of the spatial location of logistical activities is that warehousing activities are located far from cities, where the availability of large spaces is less costly. As Andreoli *et al.* (2010) point out, such leasing also enables simultaneous access to several markets, to the detriment of optimizing access to a single market, which mechanically increases volumes. A keen observer only must travel along certain motorway corridors to see, here and there, peripheral zones dedicated to warehousing, from which deliveries are organized to urban areas. The phenomenon is well known and described by economic geography through the notion of logistics sprawl (Trent & Joubert, 2022). An abundance of literature offers a range of maps highlighting the extent to which warehouses in various parts of the world are gradually moving away from urban space. More specifically, these warehouses are physically disconnected from the heart of the city, whereas history had left a legacy of logistical structures *embedded in urban space* to store essential goods.

One of the most emblematic cases is that of the famous Compagnie des Entrepôts et Magasins Généraux de Paris (EMGP), whose mission was to provide the inhabitants of the French capital with a regular supply of agricultural produce and raw materials (wheat, flour, sugar, coal, etc.). It is true that memories of the "hunger revolts" of the 18th century remained vivid in the collective unconscious of a people always ready for violent street demonstrations (Andries, 2021). The founder of the EMGP, the famous banker and businessman Jacob Emile Pereire, wanted to develop France's agricultural and industrial prosperity, taking advantage of economic liberalism and the railway revolution, which allowed goods to be transported in ways previously unthinkable. By 1864, the company had built up a vast network of warehouses in numerous Parisian buildings, most of them located in the north of Paris, along the Canal Saint-Denis and the Bassin de la Villette, in the immediate vicinity of river and rail links (see

[*] The author would like to express sincere thanks to two anonymous reviewers of the Scientific Committee of the 28th International Symposium on Logistics for their useful comments which greatly improved an earlier version of this paper.

Figure 1). Put another way, this was a veritable logistical network that lasted until the 1950s, when it gave way to TV studios.

Figure 1: The Magasins Généraux in Paris Pont de Flandre



Source: https://paris-bise-art.blogspot.com/
(Accessed April 16, 2024)

EFFECTS OF DIGITAL NOMADISM

The world of commerce and logistics is obviously nothing like it was in the late 19th and mid-20th centuries. And yet, paradoxically, logistics –especially the warehousing facilities of FMCG– are reinvesting city centers as they once did. The word "paradox" is not too strong, since for decades the managerial doxa was to consider that urban space was scarce and expensive, and should therefore be allocated primarily to commercial activities, and not to non-value-creating logistical activities. The rise of e-tailing is changing the rules of the game, even more so since the Covid-19 pandemic. As several researchers have pointed out, the urban consumer is no longer willing to go to a physical store to do his/her "ordinary shopping," whereas highly ergonomic websites make it easier to complete the purchase. It is no exaggeration to speak of a groundswell for generations Y and Z, adepts of innovative technologies and "digital nomadism" (Atanasova *et al.*, 2022), and who present themselves as propagators of an *ethic of freedom* (Mancinelli, 2020). It is also possible to refer to "liquid consumption" –based on behavior that favors flexibility, adaptability, and speed (Bardhi & Eckhardt, 2017)– which ties in with Bauman's (2000) famous work on liquid modernity.

Digital nomadism describes the behavior of consumers who actively use digital devices to access products and services without being tied to a physical location (Vanheems & Paché, 2018). The rapid evolution of connected devices has enabled consumers to be constantly online, fundamentally altering their purchasing habits enhancing immediacy. A key aspect of digital nomadism is the quest for a "seamless experience," whatever the distribution channel or device used (Chang & Li, 2022; Cocco & Demoulin, 2022). Consumers expect to be able to move seamlessly from one point of contact to another, whether in-store, on a website or on social networks. In short, digital nomadism reflects a new era in which access to information, services and products is ubiquitous, profoundly transforming the way consumers interact with brands and consume products. E-tailers are therefore faced with the challenge of creating smooth, integrated customer journeys, on the marketing side, and offering perfect product availability, on the logistics side.

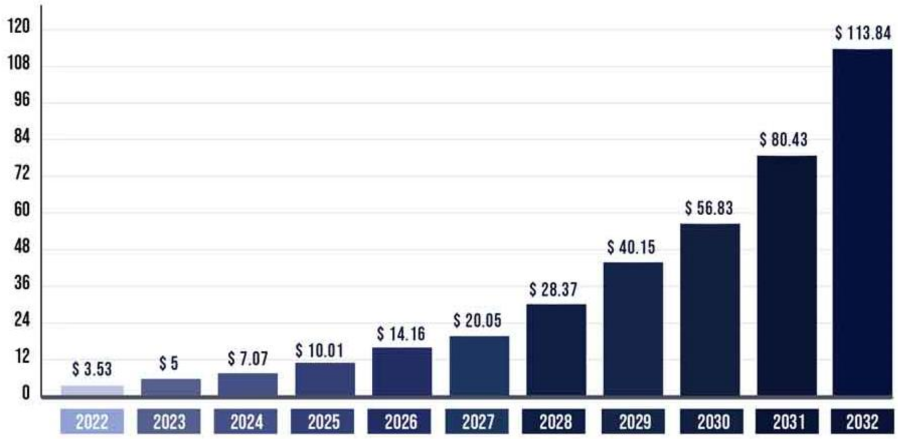
However, the growing number of online orders poses a major logistical problem in terms of delivery with the main risk being that cities will be overrun by delivery vehicles, leading to recurrent traffic jams, unexpected incidents, and road saturation (Muñoz-Villamizar *et al.*, 2021); a drone delivery solution, as suggested by Dayarian *et al.* (2020) and Pina-Pardo *et al.* (2024), seems totally unthinkable, not least for safety reasons. In addition, as mentioned above, product warehousing has gradually been relocated to the outskirts of urban areas, or even dozens of kilometers away, in ever mega-warehouses. Geographical remoteness combines with order-picking constraints to optimize the use of material and human resources. As the size of a warehouse increases, the volume to be processed mechanically increases, and the consolidation of flows becomes central; the online order of Mrs. Jones will have to be associated with the online order of nearby Ms. Smith to avoid costly vehicle movements from one city to another. It is therefore logistical optimization at order preparation level that defines the level of service offered to customers, particularly in terms of delivery times.

The fierce battle over lead times is reshuffling the deck. To capture customers who are sensitive to the near-instant availability of products, various companies have launched a mad dash for extreme reactivity. Many observers have followed with interest the first "battles" with quick commerce and its marketing promise of 15-minute delivery after an online order in several European cities (Paché, 2022a,b). In Europe, notably with the bankruptcy filings in 2023 of Turkish giant Getir in France, Italy, Portugal, and Spain, preceded by a succession of start-up failures, a hasty conclusion was drawn: quick commerce is dead on the battlefield of delay. Should we stop at these misadventures to consider that it is impossible to do better than deliver in 24 hours? This would be a main error of analysis, because delivering to a customer very quickly could soon become a unique source of customer loyalty, provided that efficient "proximity logistics" is implemented. As underlined by Buldeo Rai *et al.* (2022, p. 41): "Proximity logistics entails extending and refining networks of logistics facilities towards urban cores and allows them to counteract some of the undesirable effects that their historic tendency to outward migration (or logistics sprawl) potentially brings about."

EXPANDED SAME-DAY DELIVERY

A managerial revolution is on the horizon and the change is coming from the United States, under the aegis of the giant Amazon. What is been going on for the past few years? Amazon is clearly looking to take on Walmart, the world's largest retailer, which has positioned itself on the same-day delivery market with Walmart+, in other words, deliveries a few hours after an online order. Walmart's aim is to leverage its vast network of physical stores to pull off this logistical "*coup*," and the Walmart+ service should be seen as a direct response to Amazon Prime, costing less than the latter (but requiring a larger basket to qualify for free delivery). In response, Amazon's same-day delivery is a major area of development for the coming years and justifies massive investment in urban storage and order-picking centers, known as micro-fulfillment centers, to win the battle over lead times (Jindal *et al.*, 2021). From an operational perspective, micro-fulfillment centers are built to prepare many orders, each containing a reduced number of food and non-food items, as is often the case in online sales. As Figure 2 shows, the global market for micro-fulfillment centers should increase strongly between now and 2032, keeping pace with the growth in digital nomadism.

Figure 2: Global market for micro-fulfillment centers, from 2022 to 2032
(in billion US dollars)



Source: https://www.precedenceresearch.com/micro-fulfillment-market
(Accessed March 11, 2024)

The aim of a micro-fulfillment center is to bring products closer to the end consumer, and thus speed up delivery of the products ordered. Areas zoned for warehousing facilities are located as close as possible to residential areas. The micro-fulfillment center as urban mini hub prepares many orders containing a small number of items, as is often the case with online sales (Alessandro *et al.*, 2022). The emergence of micro-fulfillment centers has coincided with the boom in e-tailing, which has transformed consumer behaviors, including China (Xiao *et al.*, 2021). In addition to the great complexity of order management, consumers now demand ever-faster delivery, leading to massive automation of both storage and order-picking tasks. The gamble based on the application of technology in warehouses makes it possible to boost operations, improve stock management, reduce errors, and eliminate additional logistical costs. The example of Chaldal.com, an online grocery pioneer in Bangladesh, shows that the micro-fulfillment center model is now spreading to a growing number of countries, including poor ones (Gani *et al.*, 2023).

For its part, Amazon plans to build no less than 1,000 to 1,500 micro-fulfillment centers in North American cities in the next five years, leading the company to undertake massive urban expansion to reduce delivery times. This is a reversal of the old logistical strategy based on the presence of gigantic distribution centers in tax-advantaged States (Aćimović *et al.*, 2020). As early as February 2020, Amazon Prime customers in Philadelphia (Pennsylvania), Phoenix (Arizona), Orlando (Florida) and Dallas (Texas) were able to order from a list of around 100,000 of the most popular items and receive them in just a few hours: before 6 p.m. for orders placed that morning; before 1 p.m. for orders placed the night before. Expansion has continued ever since, and by 2023 at least 90 urban areas will be covered by same-day delivery, with plans to double this number by 2025. As a result, Amazon has implemented a wide-ranging strategic plan to capture urban customers, including on the Chinese market with the establishment of several urban pre-positioning warehouses (Dang, 2023).

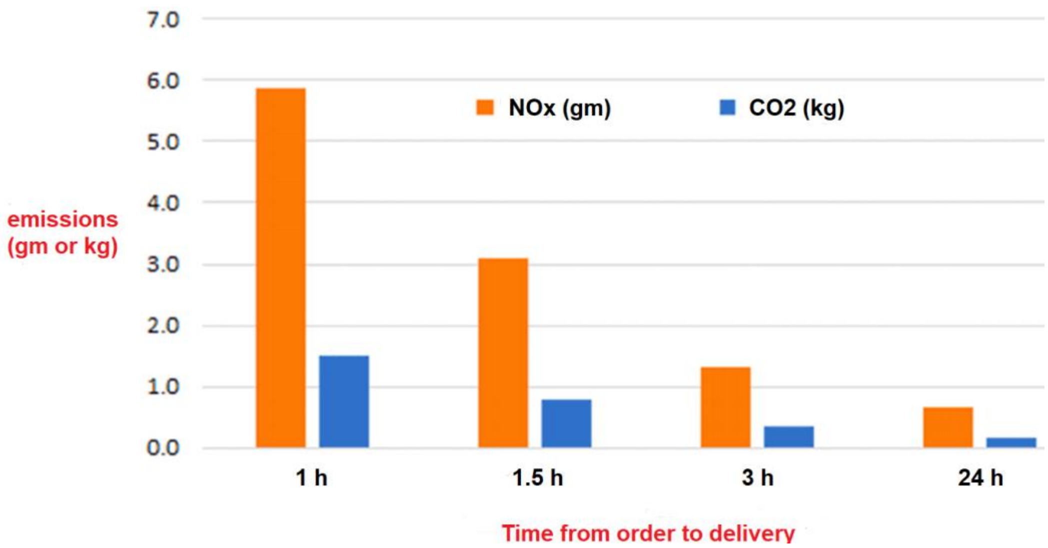
DISCUSSION AND CONCLUSION

Despite its interest and the fact that it is one of the most powerful companies on the planet, the Amazon case is certainly not unique. On the contrary, the company tends to position itself as the *avant-garde* leader of a new “proximity logistics” model that inspires other large retailers. For example, over the past year, Picard Surgelés (frozen foods) has embarked on an ambitious investment program as part of an innovative supply chain plan. The company, France’s market leader, is clearly a forerunner when it comes to logistics, since its first warehouse was built in 1976, at a time when the dominant model was still that of direct delivery to stores from manufacturers’ factories. However, Picard Surgelés is now developing a network of micro-fulfillment centers of 500 to 600 m^2, with priority given to several high-potential French cities such as Bordeaux, Paris, and Lyon. The key idea is to be able to ensure deliveries within a maximum of three hours of an online order, for a reduced product assortment. From this viewpoint, even if it is too early to speak of a "paradigm shift," major transformations in urban logistics are set to profoundly change the morphology of Western cities.

It is therefore with the utmost interest that we examine the current developments. The resurgence of warehousing facilities in the city is undoubtedly the sign of a major economic and societal mutation, the full extent of which has yet to be realized. In a detailed forward-looking analysis, the World Economic Forum (2020) underlines that in Europe, same-day delivery accounts for just 5% of all deliveries following online orders. Urban logistics specialists might therefore think that the phenomenon mentioned is no more than confetti sized. Such an error of analysis could prove dramatic, as the Covid-19 pandemic has underlined the extent to which "everything, right away" is now a commonplace behavior. Same-day delivery within a few hours of placing an order online could very quickly become a standard of service quality, and under these conditions, the micro-fulfillment center is likely to become a *structural component* of the city of tomorrow. The literature on the subject is increasingly voluminous, and on a managerial level, Ulmer (2017) already noted in the mid-2010s that same-day delivery was becoming a major business model.

The prognosis of a highly development can safely be made, and it will have major implications for urban planning and city management. Indeed, the proliferation of micro-fulfillment centers is having a negative impact on residents, particularly in terms of traffic jams and environmental degradation. As Figure 3, taken from research by the Institute for Transportation Studies, shows, reducing delivery times contributes to worsening emissions of CO_2 and fine particles. Admittedly, this is a North American context, but the results can undoubtedly be generalized. From this viewpoint, as in psychotherapy, it is possible to speak of "paradoxical injunctions." E-commerce has often been seen as an ecological alternative to traditional retailing, with fewer car journeys and delivery by a single vehicle (Van Loon *et al.*, 2015). However, same-day delivery undermines this system, not least because of the difficulty of optimizing vehicle occupancy rates and collecting several parcels on a single delivery round, especially in non-urban areas. The main question is whether consumers are aware of this situation when they order yoghurts or biscuits delivered in two hours: are they sensitive to the environmental impact of their express purchase? If not, access to transparent information could change the behavior of eco-sensitive consumers, and thus transform supply chain management.

Figure 3: CO_2 and NO_x emissions according to parcel delivery times (for the United States, 2020)



Source: Institute for Transportation Studies.

The research question introduced at the beginning of this essay was as follows: how do the expectations of a growing number of consumers in terms of the near-instant availability of products call into question old frameworks based on the logistics sprawl process? The answer is structured around three main points: (1) logistics sprawl has been explicitly called into question over the last decade, and warehousing facilities are reappearing in the heart of cities, as they did in the 19th century; (2) the movement is largely explained by the pressure exerted by consumers to be delivered very quickly after their online orders; and (3) the speed of delivery is exceptionally fast, in the order of a few hours to a few minutes, thanks to "proximity logistics" based on urban micro-fulfilment centers. As a result, a major transformation is underway, the most visible effect of which is the inescapable presence of warehousing facilities, as Le Corbusier (1933/1973) implicitly formalized in *The Athens Charter* when the author spoke of the four functions of the modern city: housing, working, recreation and traffic. Cannot the traffic function be likened in part to the optimal circulation of products in the city? However, as Haarstad *et al.* (2024) recently pointed out, freight logistics is still neglected in the analysis of urban dynamics.

Among the most significant changes, it is certainly the diversity of expectations –sometimes contradictory– of same-day delivery stakeholders that should be at the heart of future analyses. To find the most effective solutions that safeguard the living environment, all urban logistics stakeholders need to be involved in urban planning, whether private stakeholders (e-tailers, wholesalers, etc.) or public stakeholders (local authorities, residents' associations, etc.). As Sharma & Singh (2023) emphasize, only a collective and shared vision of the place of warehousing facilities in urban planning can maintain a liveable city, based on the harmonious development of commercial, recreational, and logistical activities. The challenge over the next few years is immense, and as such needs to be studied by researchers in supply chain management. While analyses conducted from an optimization perspective, such as the one by Klapp *et al.* (2018) devoted to dynamic dispatch waves problem, are essential, we should not forget that the ongoing transformation of urban logistics raises numerous societal issues that it would be dramatic to underestimate.

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A Bibliometrics Study on the Maritime Autonomous Surface Ships (MASS)

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INTRODUCTION

Autonomous technologies, particularly maritime autonomous surface ships (MASS), are increasingly prevalent in container terminal operations, maritime industries, and transportation, with researchers asserting their inevitable dominance as a means to mitigate human errors, a primary cause of maritime accidents (Yanchin & Petrov, 2020). Academic investigations primarily center on the economic benefits of MASS within the digital economy framework and delve into regulatory considerations. Additionally, research explores the digitalization of the maritime industry and the broader concept of digital industrialization (Esfahani et al., 2019; Fonseca et al., 2021; Munim & Haralambides, 2022).

Additional research into the current condition and trends of Maritime Autonomous Surface Ships (MASS) has the potential to offer valuable insights to the maritime technology sector. Leveraging automation technologies effectively can enhance user appeal and usability. Bibliometric analysis plays a pivotal role in understanding the existing research landscape, aiding in the identification of trends, prominent sources, and leading scholars in MASS studies (Bhandari, 2022; Cram et al., 2020). It also facilitates a comprehensive examination of previous studies and provides guidance for future research.

Therefore, this study aims to address key research questions regarding the progression of scholarly exploration, publication trends, academic collaborations, and prospective research directions in MASS adoption. Employing a comprehensive bibliometric analysis as its primary methodological approach, the study seeks to uncover prevailing currents and emerging trends in contemporary research within this specialized field.

RESEARCH METHOD

Bibliometric examination has evolved into a crucial tool for the assessment of research endeavors (Moral-Muñoz et al., 2020). In this current investigation, CiteSpace is employed for bibliometric analysis, being the extensively utilized and comparably accessible instrument (Chen, 2006). To get the result of bibliometric study, this research conducted two main steps, such as query string identification and information retrieval, then continue to main bibliometric analysis as depicted in the Figure 15 below.

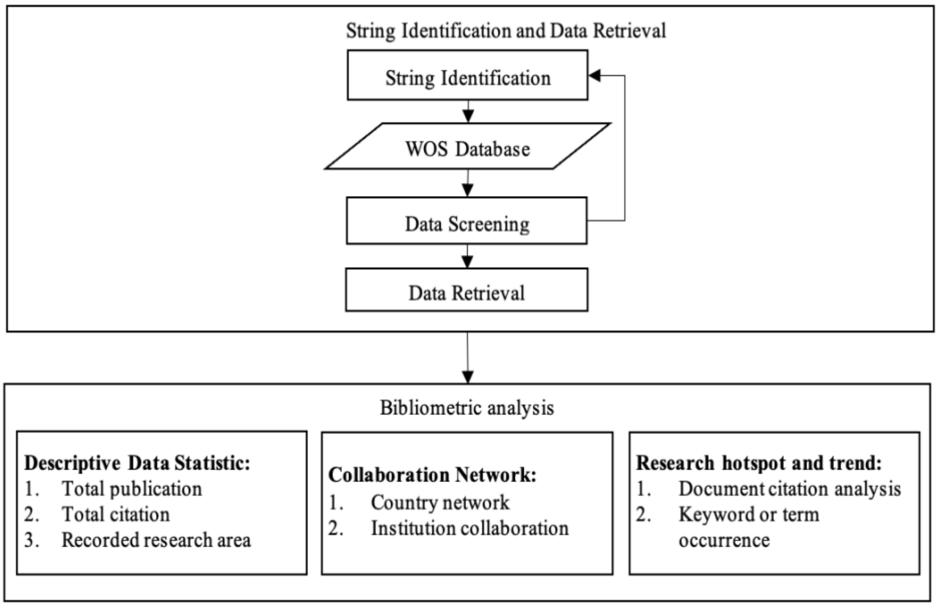


Figure 15: Research framework

Query string identification and information retrieval

The data retrieve from Web of Science (WoS) based on consideration of its capacity to offer comprehensive bibliometric data of excellent quality, owing to its wide-ranging inclusion of influential scholarly journals, as supported by prior investigations from Chadegani et al. (2013). Specifically, we began by setting the query string to "ALL=("maritime autonomous surface ship*" OR "maritime autonomous surface vehicle*" OR "autonomous ship" OR "autonomous vessel" OR "unmanned ship*" OR "unmanned vessel" OR "smart ship" OR "smart vessel") and Meeting Abstract or Editorial Material (Exclude – Document Types) and Donlon et al. (2002) (Exclude – Article)", and the search time was 19 July 2023 (article publication time was unlimited). This search string gave 612 articles to examine. Second, the source type was limited to journal articles and proceedings because they have undergone rigorous peer review and are more reliable and other types of documents.

Bibliometrics analysis

Bibliometric analysis is a systematic method used to explore and assess extensive scientific data, employing quantitative and statistical techniques such as descriptive statistics, performance analysis, cluster analysis, and science mapping to analyse bibliographic data, including publications and citations (Donthu et al., 2021; Fan et al., 2022). It helps unravel the evolutionary complexities of a research area and identifies emerging categories within it, offering valuable insights into the intellectual framework of the domain. Regardless of the focus—whether domain, methodology, or theory—bibliometric inquiries typically encompass two primary analytical categories: performance analysis, which evaluates productivity and influence, and science mapping, aimed at uncovering knowledge clusters and research collectives within a field (Donthu et al., 2021; Mukherjee et al., 2022). This research employs bibliometric analysis to present three main results: descriptive data statistics, research hotspots and trends, and collaboration networks, as illustrated in Figure 15.

FINDINGS

Descriptive data statistics

The Figure 16 represents in columns chart, depicts the cumulative number of articles published each year from 2012 to 2023. Focusing on the topic of "MASS," the publication of articles originated in 1998 with two contributions specifically in the Naval Engineers Journal. However, there was a lack of further publications until 2004, where two additional articles were published, followed by a few more in the years 2007 to 2009. Subsequently, a significant increase in publications occurred between 2012 and 2022, peaking at 188 articles in 2022. Presently, in 2023, an additional 113 articles have been published on the MASS subject.

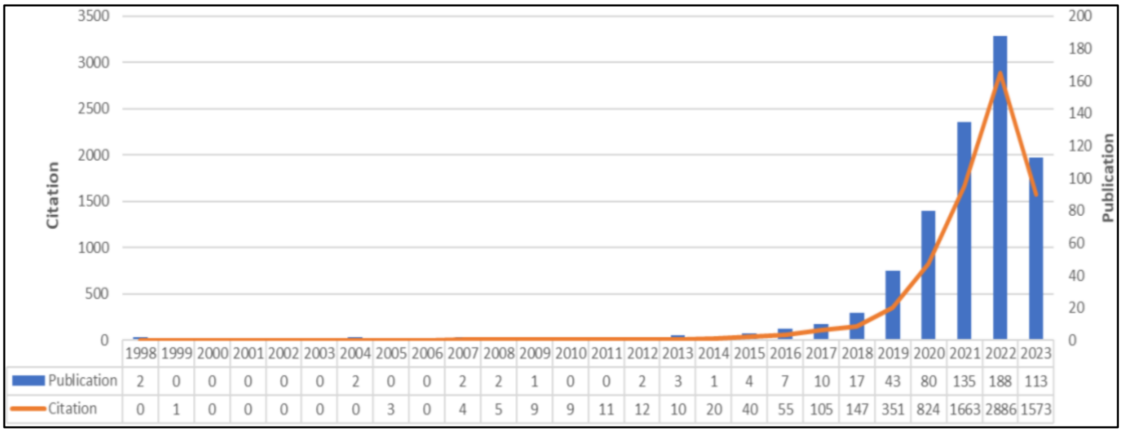


Figure 16: Total publication and citation per year

The MASS subject begins to cite actively since year 2007 with four citations and surges in 2022 that account for 2886 citations (see Figure 2 in line chart). The most active citation received in three journals namely "IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS", "IEEE TRANSACTIONS ON CYBERNETICS", and "SAFETY SCIENCE". Total 30 research area was recorded during publications year from 1998 to 2023 with "Engineering" research area for the highest total number of articles been recorded. Total 476 articles recorded for engineering research area. The second most populated research area record in "Oceanography" for total 207 articles following "Computer Science" which account for 76 articles. Therefore, Figure 17 shows the top 10 recorder research area with more than 30 articles are recorded.

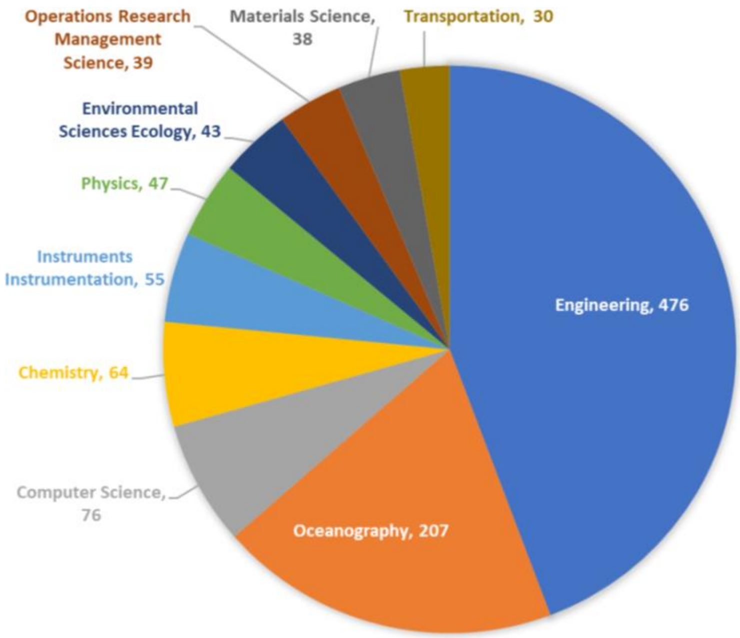


Figure 17: Top 10 recorded research area

Collaboration network

In the analysis of network clusters, an important metric for gauging their interconnectivity is the betweenness centrality score of certain nodes. Node centrality is a property in graph theory that measures the significance of a node's position within a network (Hongqiang et al., 2020). CiteSpace effectively utilizes this statistical measure to evaluate the significance of a node within the network. Nodes with high betweenness centrality scores are indicative of their crucial role in connecting different clusters. According to Shen et al., (2022), a reference is considered pivotal for the field if it possesses a betweenness centrality value of 0.1 or higher. In CiteSpace, nodes with elevated betweenness centrality scores are visually distinguished with purple trims, which vary in thickness to signify the strength of their betweenness centrality (Zhong et al., 2019).

Country collaboration

Figure 18 depicts the co-author's country network as observed in the current study. The most prominent node in the visualization represents the People's Republic of China (PRC), signifying its substantial contribution to the research in the MASS subject. Notably, PRC has published a noteworthy total of 250 publications from the year 2015 up to the date of data retrieval. South Korea (148), Norway (71), and Poland (44) respectively appear in descending order in terms of their representation in the network.

The present study has identified four countries that are considered as knowledge centers in the MASS subject area. The People's Republic of China (PRC) emerges as a critical hub in the network of MASS article publications, boasting a total centrality score of 0.52. PRC plays a pivotal role in facilitating collaborations with other countries and serves as the central point connecting three prominent countries, namely South Korea (0.27), England (0.17), and Norway (0.15), as visualized by the purple trims in Figure 18.

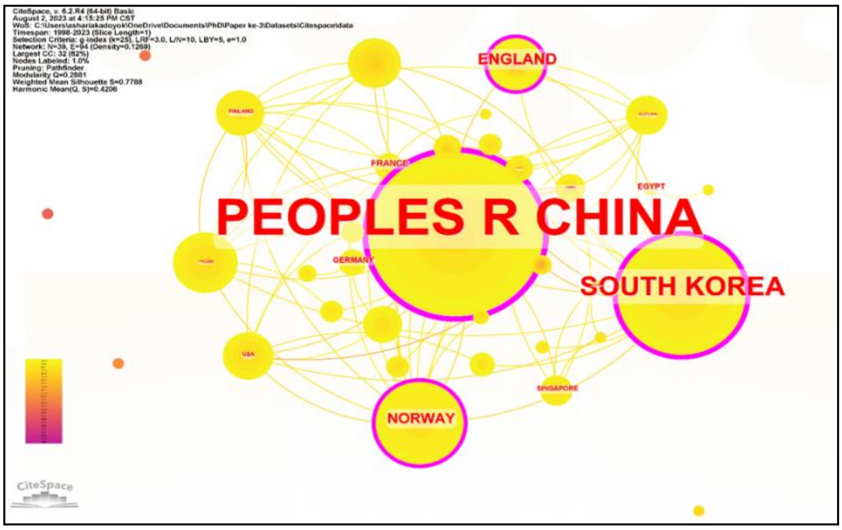


Figure 18: Country network visualization

Institution Network

As visualize in Figure 19, Dalian Maritime University stands out due to the substantial size of its node, indicating it has received the highest number of citations compared to other nodes. Dalian Maritime University has greatest number of networks that connect to the other significant node (i.e., Wuhan University of Technology, NTNU, and Jimei University). Hence, the visualization in Figure 19 assists to understand the collaborative relationships and knowledge flow within the institution.

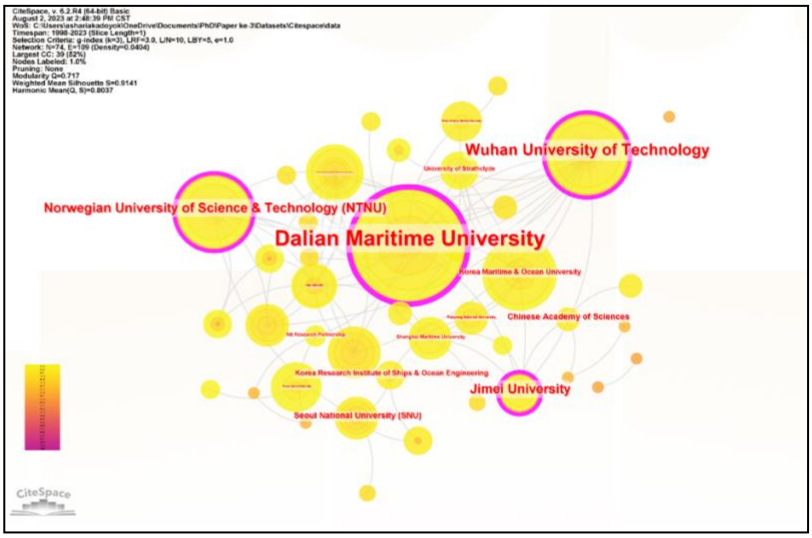


Figure 19: Institution network visualization

Specifically, the Dalian Maritime University received a total of 101 articles citation frequency. Following in second place with 54 articles is Wuhan University of Technology. The Norwegian University of Science and Technology (NTNU) is the third-ranked institution with 45 articles. With 42 articles, Korea Maritime & Ocean University occupies the fourth position. The National Engineering Research Center for Water Transport Safety, which has consisted of 24 articles, occupies the fifth spot.

Current research and future trends

Document co-citation analysis

Document co-citation analysis (DCA) constitutes one of the various bibliometric research methods employed to visualize and assess scholar relationship across diverse disciplinary domains. The technique of DCA involves gauging the similarity between documents based on their co-citation frequency, wherein they are jointly referenced by other documents (Sanguri et al., 2020). This analytical approach operates on the premise that documents are more interconnected if they share a higher number of common citations (Kumpulainen & Seppänen, 2022). When an author cites a specific document, the citation serves as an indicator, among other attributes, of an idea or a critical resource that holds significance in the author's scholarly engagement with the cited text (Small, 1973; Trujillo & Long, 2018).

Table 3 presents the top five most cited references based on citation counts, derived from the databases SSCI and SCIE. Among these references, Wróbel et al., (2017) received a notable total of 67 citations within the context of research on Maritime Autonomous Surface Ships (MASS). These authors have established themselves as prominent figures in the field of MASS safety and risk framework identification. For instance, Wróbel et al., (2017) conducted an investigation into the potential impact of unmanned vessels on maritime transportation safety, analyzing 100 shipping accidents. Similarly, C. Fan et al., (2020) proposed a comprehensive framework to identify the factors influencing navigational risk for MASS.

Citation count	**Author**	**Year**	**Title**
101	Wrobel K	2017	Towards the assessment of potential impact of unmanned vessels on maritime transportation safety
54	[Anonymous]	2021	Handbook of Marine Craft Hydrodynamics and Motion Control
45	Ramos MA	2019	Collision avoidance on maritime autonomous surface ships: Operators' tasks and human failure events
42	Fan CL	2020	A framework to identify factors influencing navigational risk for Maritime Autonomous Surface Ships
24	Huang YM	2020	Ship collision avoidance methods: State-of-the-art

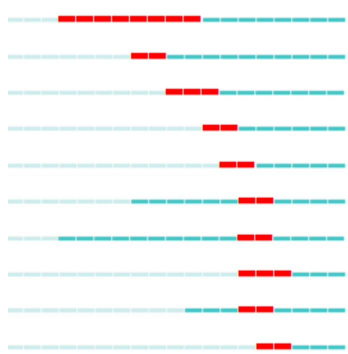
Table 3: Top five cited articles

Keyword/ term occurrences

Keywords function as concise and informative encapsulations of the content presented in research articles to identify the trending topics and the leading edges of social research methods (Catone et al., 2020). Analyzing the network of co-occurring keywords enables the identification of emerging topics within a defined realm of knowledge during a specific period (Zhong et al., 2019). Correspondingly, the evolutionary network provides valuable understanding regarding the evolution and shifts within the research field over time.

Among the identified keywords, the five most frequent ones are "autonomous ship" (frequency = 91), "system" (frequency = 88), "collision avoidance" (frequency = 87), "model" (frequency = 70), "navigation" (frequency = 56). Furthermore, considering keyword centrality scores, the top five keywords are "collision avoidance" (0.18), "obstacle avoidance" (0.18), "unmanned ship" (0.17), "system" (0.17), "navigation" (0.16). Hence, the phenomenon of keyword bursts serves as an indicator of heightened activity in a specific term within the realm of Maritime Autonomous Surface Ship (MASS) research during a particular interval.

Keywords	**Year**	**Strength**	**Begin**	**End**	**Period Time**
oil spill	2007	1.3595	2007	2009	



obstacle avoidance	2008	1.2859	2008	2015	
path planning	2012	0.9655	2012	2013	
computer vision	2014	1.318	2014	2016	
algorithm	2016	0.4638	2016	2017	
accident	2017	1.0594	2017	2018	
navigation	2012	3.2442	2018	2019	
system	2008	3.0934	2018	2019	
adaptive control	2018	2.4352	2018	2020	
unmanned ship	2015	0.9119	2018	2019	
vessel	2019	4.8598	2019	2020	
tracking control	2019	3.5388	2019	2021	
autonomous surface vehicle	2019	2.6468	2019	2021	
vehicles	2019	2.558	2019	2020	
collision	2019	2.5325	2019	2020	
smart ship	2019	2.1778	2019	2020	
autonomous vessel	2013	1.369	2019	2021	
colregs	2019	1.15	2019	2020	
containment control	2020	1.8377	2020	2021	
risk	2020	1.3042	2020	2021	
AIS data	2021	1.0016	2021	2023	

Table 4: Keywords burst in certain period

The initial instance of such a burst was observed in the term "oil spill," commencing in 2007 and persisting for a span of three years until 2009. Subsequently, the term "obstacle avoidance" commenced receiving citation bursts spanning from 2008 to 2015, signifying a comparatively more prolonged phase of burst citation activity. This prolonged duration serves as evidence that "obstacle avoidance" constituted a prominent and extensively researched keyword within the domain of MASS during that period. Notably, the presently trending keyword is "Automatic Identification System (AIS) data," having exhibited citation bursts from the year of its publication up to the present time (2021 through 2023). Detailed information concerning keyword bursts is available in Table 4.

DISCUSSION

The findings of the study unveil that research on the subject of MASS adoption has emerged in developed countries. While China assumes a prominent position in spearheading MASS adoption, however, more research is being conducted in other countries such as South Korea, Norway, England, and France. It is widely recognized that the scientific productivity across diverse research domains within a nation is significantly influenced by both its economic advancement and the contours of its public policy landscape (Liu et al., 2012). Evidently, China's is known as highly successful emerging economy and have substantial volume of patent investment towards the advancement of cutting-edge MASS technology by its scientific community (Chen et al., 2023). In recent times, China has emerged as a prominent global participant in the maritime industry.

The current study also discloses the citation burst in MASS research and adoption is happened during 2007-2023, particularly in Automatic Identification System (AIS) keyword which is having exhibited citation bursts from the year of its publication up to the present time (2021 through 2023). Citation burst is an indicator of a most active area of research. It provides evidence that a particular publication is associated with a surge of citations and has attracted an extraordinary degree of attention from its scientific community. If a cluster contains numerous nodes with strong citation bursts, then the cluster as a whole captures an active area of research or an emerging trend (Amjad et al., 2022). This finding also conforms linearly with the previous study, which discerned a notable surge in interest regarding autonomous vessels over the past decade. Subsequently, several projects have been established to study different aspects related to autonomous ships (Chae et al., 2020; Hannaford et al., 2022; Torben et al., 2023). In this field, a multitude of investigations underscored the significance of autonomous ship research in realizing the objectives of maritime policymakers for enhancing the efficiency of future shipping (Bolbot et al., 2022).

This study examines current research trends in MASS related to risk and safety. The most cited topics include maritime safety, navigational risk, and collision avoidance. One of the most cited topics is led by Wróbel et al., (2017), whose study sheds light on the potential benefits of unmanned ships in reducing navigational accidents. Similarly, C. Fan et al., (2020) proposed a framework to support the development of MASS related to risk and safety analysis, which could assist in the design and operational planning of MASS and its remote control center. These risk and safety topics also cover technological developments, such as the utilization of AIS data, which is evident from the current active citation burst. As mentioned by Sepehri et al. (2022), the concept of risk management in autonomous ships should incorporate the function of AIS technology for real-time information exchange to avoid collisions. AIS acts as a collaborative collision avoidance system in communication between MASS and conventional ships (Akdağ et al., 2022) and improves the prediction of ship trajectories (Li et al., 2024). Therefore, based on the recent active keyword "AIS data," future research is suggested to focus in this direction.

CONCLUSION

This study undertakes a comprehensive analysis of the research on Maritime Autonomous Surface Ships (MASS) with no time limitation. The research in the field of MASS gained attention gradually starting in 2007 but has experienced an exponential evolution since 2019. The latest identified trends suggest that the research field engineering, oceanography, computer science, chemistry, and instrumentation can be effectively carried out, particularly with the keyword burst in Automatic Identification System (AIS). The findings will support government, industrial sectors, and scholars with invaluable insights into the key information of research trends in the context of MASS. Such insights can be valuable for maritime policy formulations and resource allocation.

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Competitive advantage in container port sustainability performance

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INTRODUCTION

In recent discussions surrounding port sustainability, there has been a heightened focus on the need for a more comprehensive approach that goes beyond merely economic considerations. While maximising economic benefits has traditionally been a primary goal for ports, there is now a critical recognition of the need to balance economic, environmental, and social aspects to ensure long-term viability and resilience. In this sense, ports have been making considerable efforts to align their operations with sustainability principles, not only to comply with regulations but also to maintain their competitive advantage in the evolving global market. This phenomenon highlights the understanding of the increasing influence of environmentally and socially driven practices of port operations and market dynamics.

Sustainability is not just a moral imperative but also a strategic advantage for business. There is no doubt that ports that proactively integrate sustainability into their operations can enhance their reputation, attract investment, and mitigate risks associated with environmental degradation and social inequities (see, for example, Hou and Geerlings 2016). Additionally, research has acknowledged that sustainable responsibility is increasingly influential for port competitiveness (Yu et al. 2023). Traditionally, port competitiveness was determined by human and logistical resources and services in ports, but sustainability considerations have been now reshaping port market dynamics and transforming organisational processes by accelerating their internal and external capabilities to sustainable development (Hossain et al. 2021). It is thus essential for ports to understand sustainability practices and their impacts within the port sector, and design strategic actions aimed at achieving intended sustainability goals.

While there have been numerous studies to evaluate port sustainability performance in terms of effectiveness and efficiency, there is currently a notable shortage of research regarding the impact of sustainability practices on port competitiveness, highlighting the need for further investigation in this area. Hence, this research, drawing upon the Natural-Resource-Based View (NRBV), investigates the relationship between sustainability implementation and port performance, i.e. competitiveness, to understand the complex interplay between sustainability and port performance and to elucidate the concrete outcomes of sustainability in enhancing port competitiveness. Specifically, this research seeks to provide empirical evidence of the economic value of the sustainability performance of ports and propose port sustainability management strategies aimed at enhancing port business capability. Therefore, the research adopts the Structural Equation Modelling (SEM) to identify the multiple relationships between port sustainability performance and its impact on competitive outcomes and to statistically validate the reliability port sustainability activities.

The research presented in this paper was undertaken in the context of container ports, and henceforth, the term 'port' specifically refers to 'container port'. Container ports serve as pivotal nodes within global transportation and logistics networks. Given that achieving genuine sustainable development requires a holistic approach across closely interlinked sectors, it becomes imperative to analyse the capacity of container ports to generate positive outcomes in sustainable and economic domains for logistics and supply chain networks. By doing so, ports can optimise the functionality of international logistics hubs, thereby ensuring their contribution to the sustainability and competitiveness of global logistics networks.

LITERATURE REVIEW

The research employs the Natural-Resource-Based View (NRBV), an extension of the Resource-Based View (RBV), to examine the causal connections between sustainability performance and competitive advantage. The core premise of the RBV is that a firm's competitive advantage and superior performance stem from the specific types of resources and capabilities it possesses and controls (Barney 1991).

According to the RBV, an organisation's resources should be valuable, rare, inimitable, and non-substitutable, and these resources are inherently linked to performance outcomes as they generate economic rent and lasting value, contributing to the organisation's competitive advantage (Ma 2000). Recognising the significance of sustainable development as a potential source of competitive advantage for organisations, the NRBV was developed to incorporate an organisation's ability to manage and control sustainability initiatives. Drawn upon the NRBV perspective, the study proposes that a port actively developing certain sustainability practices is more likely to gain a competitive advantage because those practices may have the potential to lower costs and differentiate the port's services.

Competitive advantage in its various forms serves as a crucial metric for assessing organisational success, indicating superiority over competitors (Sigalas 2015). Porter (1991) argued that implementing well-constructed environmental management practices could positively influence technological and operational enhancements, thus reshaping competitive dynamics. Consequently, sustainability efforts have become integral components for securing a competitive edge and ensuring long-term success. The ability of ports to manage sustainability performance effectively is increasingly acknowledged as a strategic necessity (Yu et al. 2023). The idea of sustainable development offers both its holistic nature and the necessity for integration. In this sense, the multidimensional character of sustainability consistently stresses that the environmental and social sustainability performance of organisations should be closely linked with economic outcomes (Lehtonen 2004).

While the interaction between environmental and social aspects in measuring sustainable development has often been overlooked, their intertwined nature is crucial. A sustainable environment provides a stable resource foundation for societal longevity, and similarly, social sustainability entails equitable distribution of power and the fostering of eco-friendly behaviours. In the context of ports, social sustainability encompasses human resource management, such as education, health, and employment of employees who play a vital role in managing and controlling sustainability activities that impact environmental performance positively (Kim et al. 2019). Similarly, organisations have increasingly recognised that economic systems cannot be sustained without a stable supply of natural resources. Many port studies have confirmed the relationship between environmental management and economic performance. Environmental practices, such as adopting green engineering or technologies (e.g. solar panels) and energy-saving machinery, contribute to efficient operations, high-quality services, and cost savings, leading to long-term economic benefits for organisations (Sifakis and Tsoutsos 2021). This, in turn, encourages proactive planning and implementation of environmental management strategies. Furthermore, in the economic system, organisational activities directly or indirectly affect employees, consumers, and communities, impacting cultural diversity and human rights. These social impacts translate into business opportunities, leading to increased economic benefits for organisations. Satisfied employees contribute to organisational productivity and customer services, while socially responsible organisations attract more customers, enhancing brand image and market desirability. Ports that invest in employee education and training can improve worker performance, reduce accidents, and thereby enhance economic benefits through cost-saving measures and improved services (Khan 2012; Sarkar et al. 2020).

From the NRBV, the environmental strategy relies on human capital, such as the expertise and know-how of employees, to reduce pollution through ongoing improvement methods (Hart 1995). These unique skills, which are difficult to replicate, are pivotal in determining an organisation's competitive edge. While conflicting opinions have existed concerning sustainability management as a crucial determinant of port selections (e.g. Ding et al. 2019; Kaliszewski et al. 2020), some studies have highlighted the potential of sustainability activities in bolstering the competitive position of ports. For example, Acciaro et al. (2014) confirmed the positive relationship between energy management in ports and operational efficiency and economic viability, thus elevating competitiveness. Similarly, Parola et al. (2017) emphasised the role of environmental and safety-centric port management in enhancing overall operational efficiency and competitiveness through technical and procedural innovations. Other positive effects of port sustainability practices beyond operational enhancements have included increasing its public image, attracting green-oriented industries, and positioning ports advantageously against competitors (Kim and Chiang 2017). Given their dual roles as social enterprises and public agencies closely tied to regional economic development (Cheon 2017), maintaining legal and ethical standards in port management is crucial for attracting local stakeholders and securing port investments. Consequently, environmentally harmful or unethical practices by ports can lead to rejection by users or investors, potentially jeopardising their benefits and competitive standing in the market. Additionally, the discussion on the interconnectedness between environmental, social, and economic sustainability, and the competitive advantage of ports posits the mediating role of the three sustainability aspects on competitive advantage. Therefore, based on the discussion above, the research developed nine hypotheses, as summarised in Table 1.

Hypothesis	Description
Hypothesis 1	Port social sustainability has a positive influence on port environmental sustainability.
Hypothesis 2	Port social sustainability has a positive influence on port economic sustainability.
Hypothesis 3	Port environmental sustainability has a positive influence on port economic sustainability.
Hypothesis 4	The implementation of environmental sustainability has a positive influence on the achievement of a competitive advantage of ports.
Hypothesis 5	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports.
Hypothesis 6	The implementation of economic sustainability has a positive influence on the achievement of a competitive advantage.
Hypothesis 7	The implementation of environmental sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by economic sustainability.
Hypothesis 8	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by environmental sustainability.
Hypothesis 9	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by economic sustainability.

Table 1: Research hypotheses of the study[8]

RESEARCH METHODOLOGY

This study utilised a survey methodology to collect data, employing a web-based questionnaire designed for individuals to be completed and submitted through online service software. The questionnaire comprised two main sections: Part A, which addressed the hypothesised relationships; and Part B, which gathered demographic information of respondents. The measurement items for the study constructs related to port sustainability aspects were primarily derived from key performance indicators synthesised by Lim et al. (2019). Additionally, the measurement items for competitive advantage were developed based on previous research across diverse disciplines, including the port research area (e.g. Lirn et al. 2014; Lu et al. 2016; Walsh and Dodds 2017). In total, 39 items were initially formulated and measured using a Likert scale, where respondents rated their level of agreement on a scale from 1 to 7. 1 represented "Strongly disagree" and 7 denoted "Strongly agree". Examples of questions included, 'My port/terminal has provided employee training and education' and 'Controlling deterioration of water quality strengthens the competitive advantage of my port/terminal'. The questionnaire was distributed to professionals at the management level, from frontline- to top-level managers in container ports and

[8] The research hypotheses follow a process developed in research by Lim (2022).

terminals around the world. The survey was carried out over a period of five months, from March to July for five months in 2020.

ANALYSIS

Descriptive analysis

A total of 248 completed questionnaires were returned, resulting in a response rate of 49%, which is considered acceptable for SEM research (Hox et al., 2010). The data were collected from 37 countries, with the largest number of ports located in the United States (8.9%), followed by Brazil (7.3%), Malaysia (6.9%), and Great Britain (6.0%). The 37 countries were further grouped based on the continents. The majority of responses came from Europe (25%), followed by East and Southeast Asia (24%), and Oceania (11%). Africa accounted for the smallest proportion of responses, at 6%. In terms of port size, based on annual container throughput, more than half of the respondents (53%) worked in medium-sized ports, followed by small-sized ports (23%) and large-sized ports (21%). Regarding the management levels of respondents in their ports, more than half of the respondents (58%) were middle-level managers, while front-line and top-level managers accounted for 27% and 14%, respectively. Furthermore, the largest group of respondents had more than 15 years of working experience (39.1%), followed by those with between 1 and 5 years (25.4%), 6 to 10 years (17.3%), and 11 to 15 years (12.5%) of experience. Only a small proportion (2.8%) had less than one years work experience in the port industry.

EFA and CFA analyses

The information collected went through a data preparation process involving screening for missing data and outliers. Following the treatment process, a total of 236 usable responses remained. The initial theoretical model underwent a pre-test via EFA to refine the variables and eliminate unnecessary items and noise. The EFA followed procedures outlined by Costello and Osborne (2005) and Hair et al. (2014). After the EFA analysis, decisions were made to remove inappropriate variables, including those with cross-loadings. Consequently, 26 out of 39 variables were retained for the further analysis. The reliability and validity of the variables post-EFA were further confirmed by satisfying the Kaiser-Meyer-Olkin (KMO), which indicated an overall value of 0.927, with each construct scoring greater than 0.80. Additionally, Bartlett's test of sphericity showed significance for both overall and individual constructs.

CFA was carried out to assess the validity of the measurement model, which consisted of four constructs: Competitive Advantage (CA, 6 variables), Environmental Sustainability (EN, 8 variables), Social Sustainability (SO, 6 variables), and Economic Sustainability (ES, 6 variables). All standardised factor loadings exceeded 0.60, indicating their significance in the model (Figure 1). Additionally, all variables demonstrated significant t-values at $p < 0.001$. The overall measurement model demonstrated a favourable fit to the data, satisfying recommended thresholds for goodness-of-fit indices ($\chi^2/df=2.045$; SRMR=0.0535; CFI=0.916; IFI=0.917; TLI=0.907; RMSEA=0.067). Furthermore, the CFA results confirmed the unidimensional nature of the study constructs, with correlation estimates among the constructs below 0.80.

Research hypotheses testing

Following the successful assessment of the goodness-of-fit measures by the overall CFA model, the proposed structural model showed identical model fit results to the CFA model, providing support for the study's proposed model. Figure 1 illustrates the standardised paths representing the final results of structural equation modelling.

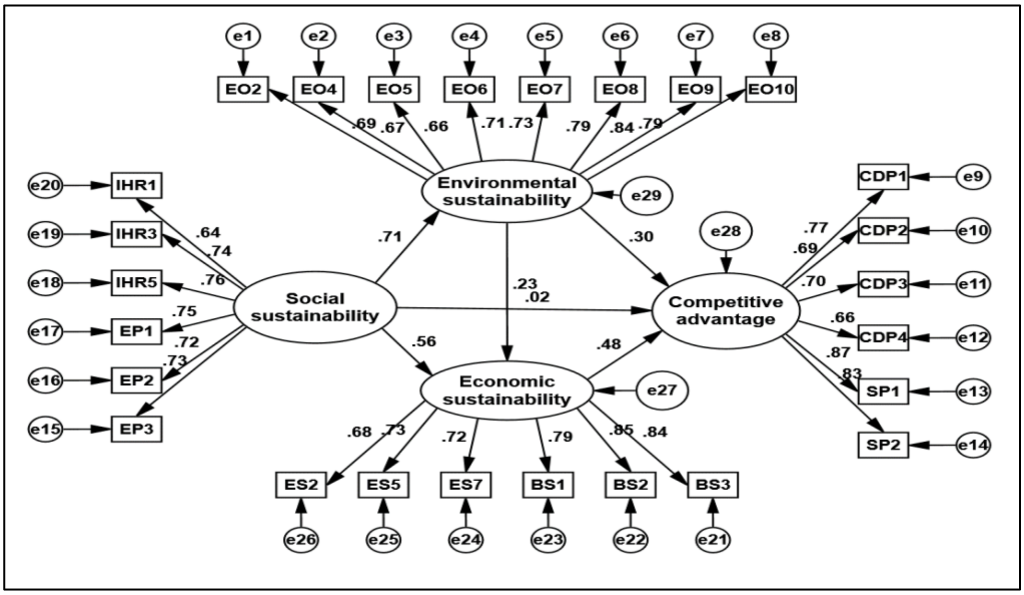

Figure1: Final structural equation modelling results

The nine established hypotheses of the study were tested, examining the causal relationships regarding the direct and indirect effects among the four constructs. The overall results of hypothesis testing, including p-value indicating statistical significance, are summarised in Table 2.

Hypothesis	Hypothesised relationship	p-value	Result
H1	SO → EN	***	Supported
H2	SO → EC	***	Supported
H3	EN → EC	**	Supported
H4	EN→ CA	***	Supported
H5	SO → CA	0.858	Not supported
H6	EC → CA	***	Supported
H7	EN → EC → CA	*	Supported
H8	SO→ EN →CA	***	Supported
H9	SO→ EC →CA	**	Supported

Table 2: Overview of hypothesis testing results (***: $p < 0.001$, **: $p < 0.01$, $*: p < 0.05$)

All hypotheses were validated except for hypothesis 5, which concerns the direct impact of social sustainability on competitive advantage. It is, however, interesting to note that this relationship demonstrated statistical significance when considering the indirect effects of environmental and economic aspects on this pathway. Consequently, all indirect paths were fully supported, affirming the mediating effects of the relationships among them.

DISCUSSION

The significant relationships regarding the interdependence among environmental, social, and economic aspects of sustainability suggest that container ports are progressing towards sustainability as intended by port sustainability management objectives, which aim for a balanced approach encompassing environmental and social responsibility alongside economic benefits. The stronger correlation observed between environmental and social performance (standardised coefficient=0.706) compared to that between environmental and economic performance (0.229) or social and economic performance (0.563) indicates the potential for a stronger interface between environmental and social factors in port operations. This may imply that ports can harness mutual or complementary benefits by integrating environmental and social sustainability frameworks, suggesting the importance of actively developing eco-social practices, such as safety and environmental management training programmes and waste-to-energy projects. Furthermore, the results indicate significant direct effects of sustainability performance from both environmental and economic aspects on enhancing the competitive positioning of ports. This implies that container ports can gain competitive advantages by implementing and emphasising environmental and economic sustainability-related practices or activities. These practices can contribute to differentiating the port in terms of reputation, services, technology, and user satisfaction. The finding provides empirical evidence strengthening the previous argument in port research that sustainability initiatives have enhanced port competitiveness and overall port performance in terms of effectiveness and efficiency (e.g. Lun 2011; Yuen and Thai 2017).

The observation of mediated effects between social performance and port competitive advantage through environmental and economic performance suggests that the robustness of social sustainability performance in enhancing competitive advantage relies on the supportive roles of environmental and economic sustainability initiatives. Thus, container ports with stronger pollution prevention and economic development strategies are more likely to generate higher levels of social performance. This further emphasises the critical role of intervention and support from environmental and economic sustainability efforts to drive positive social sustainability outcomes, thereby elevating port competitiveness. This argument resonates with research in the field of sustainability business management, which has emphasised that a sequential interdependence of sustainability practices fosters synergistic interactions, ultimately enhancing organisational performance and competitiveness (Galeazzo et al. 2014; McDougall et al. 2021).

However, the weak direct relationship between social performance and competitiveness may suggest a lack of systematic approaches to address societal issues within the port industry. This observation also implies that the structure of social sustainability is complex, intertwined with environmental and economic sustainability activities. This complexity poses challenges in accurately predicting and tackling specific societal-related operations, particularly for individual ports. Hence, the findings suggest the imperative need for collective efforts through organised networks, such as the ESPO’s EcoPorts project (ESPO, 2012), in order for both individual ports and the entire port sector to reap the benefit of social sustainability practices. By doing so, ports can facilitate more robust social practices and policies and significantly enhance the balanced effectiveness of sustainability performance and the competitive advantage of ports.

CONCLUSION

This study examined the relationship between sustainability performance and its influence on strengthening port competitiveness advantage. Through the exploration of nine hypotheses, the study evidenced positive associations between port sustainability performance and competitive advantage, with the exception of a direct link between social performance and competitive advantage. However, this relationship is further substantiated by the full mediation of environmental and economic performance factors. The findings offer significant insights into the status of ports concerning sustainability progress and its consequential impacts on port operational performance in terms of competitive advantage. In this sense, the study contributes to providing decision-makers in container ports with evidence regarding the rationale of sustainability performance and facilitating the development of optimal practices in port sustainability management with holistic sustainability management strategies. Moreover, this research enriches the theoretical discourse on port sustainability management by elucidating the linkage between sustainability performance and competitive advantage through the lens of the NRBV.

Although this study implicitly encompasses Key Performance Indicators (KPIs) pertinent to port sustainability performance, it suggests that the methodological approach and metrics from SEM could be explicitly extended into the development of a KPI framework for future assessments of port sustainability performance. Furthermore, it is important to acknowledge that the findings of this study may have limited applicability and generalisation to current circumstances due to the time elapsed since data collection. Especially, as a consequence of the COVID-19 pandemic, pertinent perceptions of sustainability performance within ports may have evolved, necessitating future studies to capture more recent data. Such investigation would enable a more appropriate reflection of the current landscape and facilitate the discernment of nuanced shifts in sustainability perceptions and their impacts on port performance.

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Developing a Border Performance Index: Empirical Evidence from Thailand

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INTRODUCTION

International trade worldwide contributes to global economic growth. Evidence indicates that national borders influence international trade. For example, transaction costs, custom standards and procedures, and regulatory differences could increase the transaction costs for shipments crossing borders (Chen, 2004). Logistics performance in terms of time, cost, and reliability on global bilateral trade also has an impact on the efficiency and effectiveness of border processes in trade (Djankov et al., 2010; Sharafeyeva and Shepherd, 2020).

Governments and policymakers are concerned on the border processes in trade and any barriers to such processes. Consequently, the World Bank's Doing Business project introduced the Trading Across Borders (TAB), which has been utilized to evaluate the border processes. The TAB has also been used as a proxy to assess a country's border performance (Sharafeyeva and Shepherd, 2020). However, the World Bank's Doing Business project has been terminated recently. Therefore, this study aims to propose a performance measurement tool called the Border Performance Index (BPI) as an alternative indicator for evaluating border processes in trade. The scope of this study limits to inland border checkpoints (i.e., excluded seaport/airport border checkpoints).

LITERATURE REVIEW

Banomyong's macro logistics system (2008) (Figure 1) was employed as a theoretical foundation for developing the BPI. The macro logistics system comprises four dimensions. The definitions of these four dimensions were extended to align with the context of border processes related to trade.

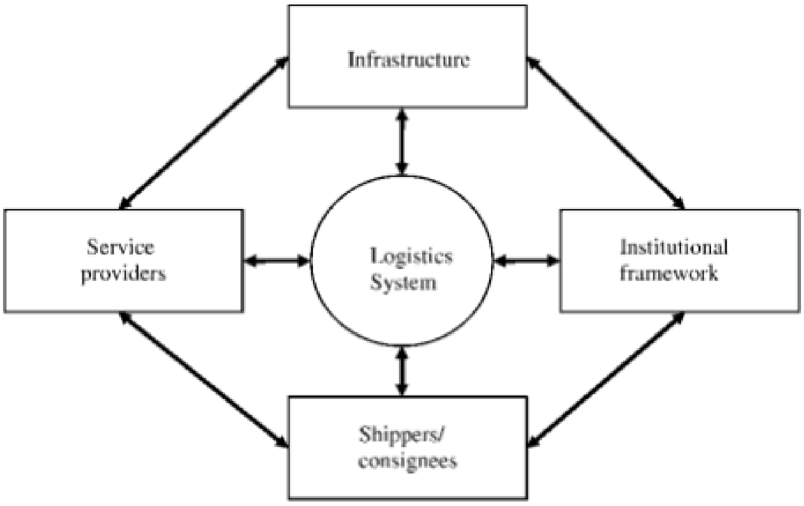

Figure 2: The macro logistics system (Banomyong, 2008)

Based on the border-focused definitions shown in Table 1 and 2, it was observed that there were relevant indicators that can be used to assess border processes in trade. These include (1) the OECD's Trade Facilitation Indicators (TFIs) developed by the Organisation for Economic Co-operation and Development (OECD) and (2) DIFOT or delivery in full and on time. The TFIs provide a set of measures that were developed to help governments to assess and improve their border procedures (TFI, 2018). It composes of questions aimed to gather data on country policies in trade facilitation in relation to border procedures. Thus, the TFIs are relevant to the infrastructure dimension (the hardware side) and the institutional framework dimension (the software side).

Table 1: Definitions of the infrastructure dimension and the institutional dimension

Dimension	The macro logistics system	Operationalized for the BPI
Infrastructure	It is the hardware of the macro logistics system. It includes transport infrastructure, which is critical for the physical movements and storage of shipments, and communications infrastructure, which is critical for the efficiency of these movements, particularly across borders and modal interface areas, where customs and other related agencies.	It is the infrastructure built for border trade. This includes the physical assets and systems that facilitate the movement of goods across international borders. These infrastructures are, for example, roads and bridges that are essential for transporting goods between countries. Warehouses and storage facilities near borders for temporarily storing goods that are waiting for customs clearance or further distribution. Inspection stations used for inspecting goods to ensure the import/export requirements and regulations (e.g., X-ray machines, quarantine facilities, and weigh stations).
Institutional framework	It is the software of the macro logistics system. It includes rules and regulations concerning imports and exports, financial regulations (e.g. letter of credit rules and ability to exchange currency), registration and licensing of service providers, customs procedures, border crossing procedures, and the type of logistics services that can be offered.	It involves customs procedures related to documentation requirements, import/export tariffs, inspections, and efficient bureaucratic processes to minimize delay: for example, harmonization (international agreements initiated to reduce friction in cross-border trade), coordination and cooperation between multiple cross-border government agencies (they worked together to ensure efficient and secure trade flows), consultation and dialogue performed between the public and private sectors that addresses bottlenecks and improves the trade environment, and capacity building initiated by international organizations and advanced economies who assist developing countries in strengthening their institutional capacity for trade facilitation.

DIFOT is a fundamental measurement of logistics or delivery performance within a supply chain. It is used to assess the performance of internal supply chain core activity such as customer service and support (Banomyong and Supatn, 2011). In other words, it assesses whether or not the supply chain can deliver the ordered product to a location specified by the customer, in the correct quantity requested within the time period requested by the customer. Thus, DIFOT is a measurement for the users of the macro logistics system: LSPs and shippers/ consignees.

Table 2: Definitions of the logistics service provider dimension and the shippers/consignees dimension

Dimension	The macro logistics system	Operationalized for the BPI
Logistics service providers	They are public and private LSPs doing businesses in the logistics industry. They provide logistics services related to transport, warehouse, storage, sourcing, and managing inventory.	They are public and private LSPs doing businesses related to cross-border logistics. They provide logistics services including transport, warehouse, storage, sourcing, and managing inventory, particularly related to border crossing and transshipment activities.
Shippers/ consignees	They are the users of the macro logistics system who move their goods through the macro logistics system effectively and efficiently, both as inputs to and outputs from their businesses. They are involved with the macro logistics system both within and outside of the domestic environment.	They are the users of the macro logistics system who move their goods across borders. The scope also includes the movement of goods for transshipment activities that occurred within the domestic areas.

METHODOLOGY

The context of study

The context of study was the border checkpoints of Thailand. A stakeholder analysis (Varvasovszky & Brugha, 2000) was adapted to identify stakeholders involved with border processes in trade occurred at the border checkpoints of Thailand. The scope was the shipments transported through inland border checkpoints, thus, excluding seaports and airports. Consistent with the macro logistics system framework, the analysis revealed two groups of stakeholders: the government officers who performed and controlled the processes at the border checkpoints (custom officers, immigration officers, quarantine officers, and public health officer) and the users of the border processes (goods owners, traders, LSPs, custom brokers, and truck drivers).

The development of the Border Performance Index (BPI)

A development was carried out through two steps: determining the questions and refining the questions. First, Q-methodology (Brown, 2019) was employed to select the TFIs for this study. This was because the TFIs include 133 variables organized by 11 policy dimensions; however, not all variables should be included in the BPI. Five experts in the fields related to border procedures and logistics activities (logistics, international trade, border development, policy, and customs) participated in this sorting task. The result of sorting revealed that the experts suggested 20 indicators, with an acceptable internal reliability level (70%) (Hinkin et al., 1997). The scale of each question derived from the TFIs was adapted from the TFI and ranged from 0 (below expectation) to 1 (as expected), and to 2 (above expectation).

Three questions adapted from DIFOT were used: delivery time, quantity, and the time spent for border procedures. The scale was modified to fit with the TFIs and ranged from 0 (below expectation or more than 10% of the orders could not delivered in full or on time) to 1 (as expected or around 5-10% of the orders could not delivered in full or on time) to 2 (above expectation or less than 5% of the orders could not delivered in full or on time).

Second, the initial version was translated from English to Thai and validated using back translation. To validate the BPI questionnaire with the border trade context, the Thai-version was piloted with 12 respondents from the government and the users. The BPI questionnaire was refined, finalized, and ready to use.

Data collection

The BPI questionnaire was implemented at nine border checkpoints in Thailand, selected based on five criteria: the import-export volumes, the readiness of transport infrastructures, the numbers of hinterland businesses, the number of labor forces, and the positive economic growth trends. The BPI questionnaire was deployed, from September 2022 to October 2022, to these nine border checkpoints where the respondents were the government (CIQ) and the users (traders, LSPs, custom brokers, and truck drivers).

Totally, the 'government' respondents were 129 while the 'users' respondents were 1,620, specifically, 12 and 205 at Border 1, 17 and 197 at Border 2, 14 and 199 at Border 3, 14 and 142 at Border 4, 12 and 192 at Border 5, 12 and 156 at Border 6, 14 and 199 at Border 7, 15 and 127 at Border 8, and 14 and 190 at Border 9.

Data analysis

The obtained scores from each respondent were included in each of the macro logistics system dimensions, to obtain a BPI score for the border under study. The score ranged from 0 for the low performance to 1 for the adequate performance and 2 for the high performance. These ranges suggest areas where border processes are efficient or inefficient and meet or exceed the respondents' perceptions. A higher BPI score for a particular dimension suggests better border performance on such a dimension. Scores between 1 to 2 suggest that the performance is adequate or better than expected. Scores below 1 indicate that the performance is lower than expected and needs improvement.

A score of each area was calculated by averaging the scores across four dimensions. A border, thus, has a set of scores (a total score and a score for each dimension). Interpreting these scores is the same as the individual score for each dimension. For example, a higher total BPI score indicates better overall border performance.

Ranking method

To make the BPI results interpretable and comparable, the methodology of World Bank's LPI was adapted (LPI, 2023). The LPI assesses overall logistics performance across countries based on surveys from service providers. It categorizes countries into groups like Logistics-unfriendly, Partial performers, Consistent performers, and Logistics-friendly based on their scores.

In this study, the nine borders were ranked according to each dimension, and the rankings were categorized into tertiles: The higher performers are borders that score high across all or most dimensions, indicating efficient and effective border operations. The consistent performers are borders with consistent performance across dimensions, though there may be room for improvement. The partial performers are borders where performance is mixed or below average in several dimensions, indicating significant areas for improvement.

RESULTS

The BPI scores encompass five types: the total, the infrastructure dimension, the institutional framework dimension, the LSP dimension, and the shippers/consignee dimension. Table 3 reports scores of all borders under study. These scores represent a snapshot of each border's performance, providing insights into where improvements can be made. Higher scores indicate better performance across the evaluated dimensions, while lower scores highlight areas for improvement. The goal for each border is to enhance their BPI score by addressing identified weaknesses and leveraging their strengths for better border management and trade facilitation.

Interpretation can be made from Table 3. For example, Border 1 has a total score of 1.055 and relatively lower scores on infrastructure and regulatory processes, suggesting it requires significant improvement in infrastructure, regulatory processes, and interactions with LSPs and shippers/consignees. However, Border 1 has relatively higher scores on LSPs and shippers/consignees. Border 2 is similar to Border 1 in that both have lower total scores, but Border 1 has adequate score in the infrastructure and institutional dimensions.

Table 3: Scores of all borders

Border	Total	Infrastructure	Institutional	LSPs	Shippers/ consignee
1	1.055	0.539	1.098	1.288	1.294
2	1.077	0.752	1.173	1.199	1.183
3	1.098	0.733	1.245	1.255	1.159
4	1.115	0.774	1.179	1.268	1.240
5	1.118	0.624	1.144	1.359	1.344
6	1.149	0.788	1.265	1.219	1.325
7	1.151	0.810	1.210	1.189	1.393
8	1.179	0.906	1.171	1.254	1.387
9	1.188	0.697	1.305	1.246	1.506

However, interpreting raw scores is quite challenging and this is where the BPI ranking comes into play its role. Figure 2 illustrates a BPI ranking of total scores. It is observed that the performances look indifferent, at one decimal. However, when using three decimals, the differences are observed (Figure 3).

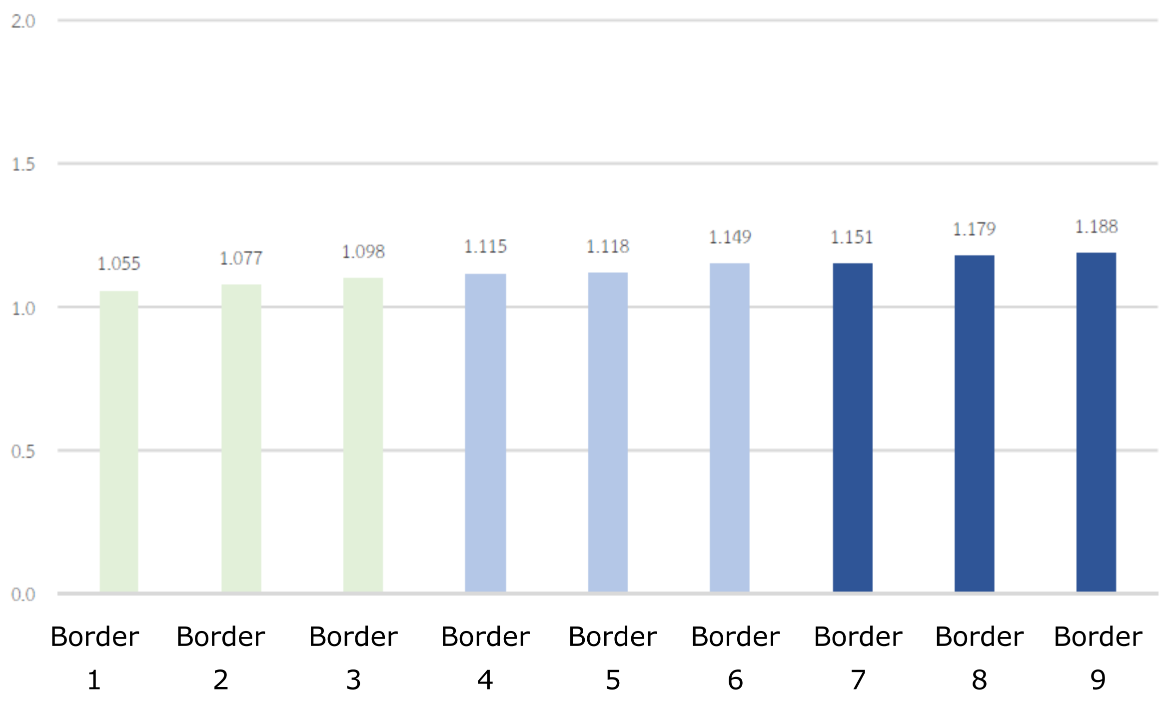

Figure 2: The ranking of total scores (one decimal)

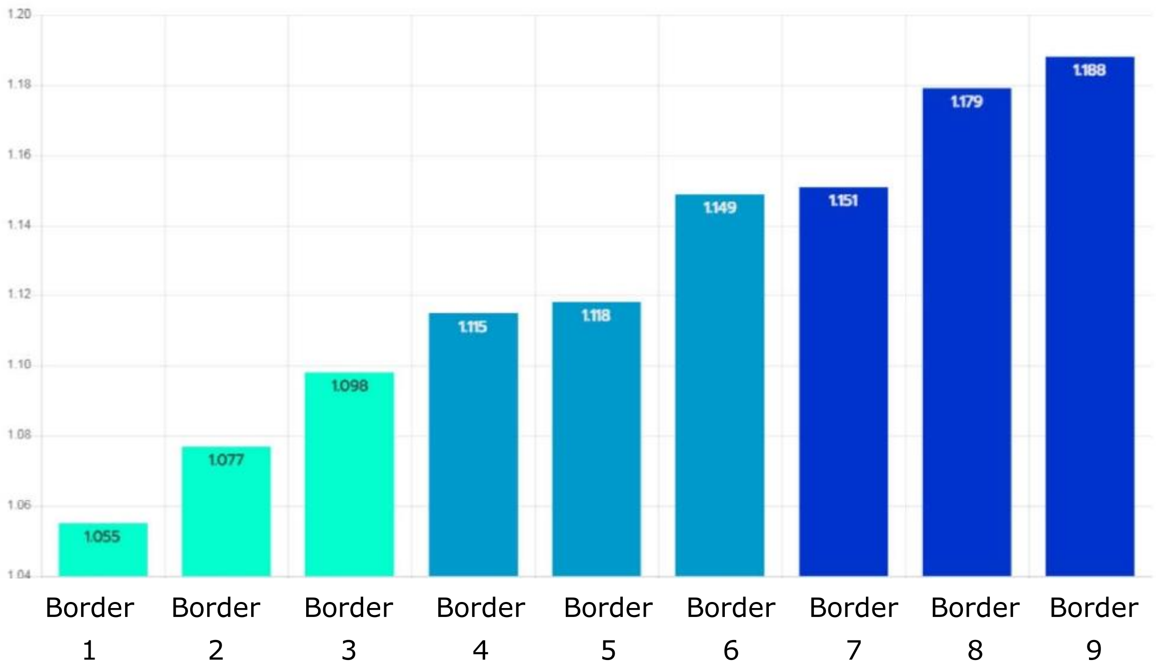

Figure 3: The ranking of total scores (three decimals)

DISCUSSIONS

The BPI is an alternative tool designed to assess the efficiency and effectiveness of border processes in trade, specifically at border locations. As in examples provided above, the BPI can be used to identify areas needing improvement, benchmark performance among borders, and monitor the impact of improvement made to each border. The strength of the BPI lies in its ability to provide a comprehensive and objective measurement of border operations' efficiency by offering a detailed assessment through four dimensions: infrastructure efficiency, regulatory compliances and customs procedures, and the performances of LSPs and shippers/consignees. For a national level, the BPI enables policymakers and governments to benchmark their border performances. At a global level, the BPI should help countries to benchmark their performance against global standards, fostering a competitive environment for trade facilitation improvements.

Comparing the BPI and the LPI, both differ primarily in their scope and focus. The BPI focuses on the efficiency of border processes related to trade and assesses the ease and speed of moving goods across borders. In contrast, the LPI is broader and evaluates the overall logistics environment within a country, encompassing factors like infrastructure quality, international shipments, logistics competence, tracking and tracing of shipments, and the ease of arranging competitively priced shipments.

Another interesting point is that the obtained scores are very close and require at least 3 decimals to clearly separate the performance of each border. This suggests that the respondents might not feel any difference between borders. However, it might be because a score was combined between the perceptions of users and those of the government officers who provide border services. The interpretation of BPI scores may be influenced by the diversity of respondents and the subjective nature of some survey questions.

CONCLUSION

The study introduces the Border Performance Index (BPI) as an indicator for evaluating border performance, positioned as an alternative to the terminated Trading Across Borders (TAB) initiative. BPI comprises questionnaires designed to gather perceptions from two key stakeholder groups: users (traders, logistics service providers, custom brokers, and truck drivers) and service providers (Customs, Immigration, and Quarantine - CIQ) engaged in cross-border trade. The validation of BPI questionnaires was conducted at nine border checkpoints in Thailand.

The BPI's comparative aspect makes it adaptable for policy development, allowing the creation of initiatives tailored to specific geographical locations, such as borders, regions, or country clusters. Policymakers, practitioners, and governments can utilize the BPI as a proxy to evaluate and monitor their border performance. It can be used as a valuable benchmarking tool that allows for the comparison of performances among different border checkpoints, aiding in the identification of areas for improvement and best practices.

Similar to the Logistics Performance Index (LPI), the BPI evaluates perceptual responses related to border performance. To improve the BPI, further development could involve the incorporation of practical indicators such as lead time, delays, and the number of documents used. Additionally, the BPI in this study focused on assessing users and providers involved in border trade on the Thailand side. The next step involves utilizing the BPI to evaluate the borders of Thailand's trading partners, specifically the counterparts on the other sides of the nine border checkpoints. This comparison will enable an assessment of the performance of Thailand's border checkpoints relative to those of its trading partners.

The BPI has been developed for inland border checkpoints. Future research should expand an investigation to seaports and airports and maybe integrate them into the BPI framework. Another interesting future research is to investigate sensitive issues that could not be carried out in this paper, which its indicators were derived from the TFIs and DIFOT. For example, an issue like corruption practices can have an impact on logistics costs may be developed as a assessment framework used in complementary with the BPI.

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