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(ISL 2023)

Managing Supply Chains during Geopolitical Turbulence

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INTRODUCTION

We are delighted to welcome our friends and colleagues, both old and new to the 27th 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 conflict between Russia and Ukraine, the trade war between China and the USA and the environmental uncertainties which we debated extensively during the last year's ISL in Cork. 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 and logistics costs. Other issues such as delays in shipments, 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, like last year, decided to continue with the hybrid mode again this year, which worked quite well in Cork during the ISL 2022. Whilst the hybrid mode is not an ideal context to network, but 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 type 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 the part 2 of the Proceedings of the Conference with an ISBN number. The second category of papers that were invited were labelled as 'Working Papers'. These may be considered as developmental, representing early-stage research ideas or initial findings. Only the abstract was required for the initial submission, which underwent the review process. If accepted, the authors were requested to submit an expanded (between 4-6 pages) version of the abstract. These Working Papers were made available on the ISL ConfTool portal for a limited period so that the registered delegates could access these during the event. However, only the abstracts of the working papers appear in this set of proceedings in part 1. It is expected that the submitted Working Papers would be significantly changed for any subsequent journal publication. Both types of paper submissions – working papers and full papers – were considered for publication in 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 10 minutes during the two-day event.

Considering the current volatile situation around the world due to the ongoing conflict between Russia and Ukraine and its subsequent impact on global supply chains, this year's theme was chosen as *'Managing Supply Chains during Geopolitical Turbulence'*. This 27th 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 27th 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 delegates. We are delighted with the success in terms of number of submissions resulting in 62 paper

presentations representing authors from 26 countries. In addition to this, we were fortunate to have two excellent keynote speakers namely Prof Rob Zuidwijk, Rotterdam School of Management, Netherlands and Pieter Bootsma is Chief Strategy Officer for Air France-KLM Group. We were also pleased to host a workshop on *'Towards Industry 5.0: Implication for Supply Chains'* ably led by our colleagues Dr. Christos Braziotis (University of Nottingham, UK), Dr. Maria Pia Ciano (University of Nottingham, UK) and Dr. Engin Topan, University of Twente, Netherlands.

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 a user-friendly 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, despite travel restrictions and general concerns with the pandemic.

As mentioned above, like 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

- Sustainability in Logistics and Supply Chain Management
- Globalisation of Supply Chains
- Supply Chain Analytics
- Smart/Digital Logistics and Supply Chain Management
- Building Resilience for Supply Chains
- Logistics Network Design
- Transport & Distribution
- Customer-Supplier Relations
- Manufacturing logistics

Part II: Full Papers

- Sustainability in Logistics and Supply Chain Management
- Supply Chain Analytics
- Smart/Digital Logistics and Supply Chain Management
- Building Resilience for Supply Chains
- Transport & Distribution
- Customer-Supplier Relations
- Manufacturing logistics

To date ISL has been held in Europe, Africa, Australia and Asia (see full list below), and the last event was held online. 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. Prof Harold Krikke, Open University, Netherland deserves a special mention for his unwavering support, advice, guidance as well as identifying and inviting the keynote speakers. Finally, our special thanks go to Professor Ian Gibson, University of Twente - Fraunhofer Innovation Platform for Advanced Manufacturing, for hosting the event at the University of Twente, Mirjam Renema, UT-FIP for the excellent organisational support for the entire event. We are also indebted to Elias Rouchou (UT-FIP) for organising the industrial visit to BOLK.

Professor Andrew Potter and Professor Kulwant S Pawar – July 2023

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Transport & Distribution

Customer-Supplier Relations

Manufacturing logistics

WORKING PAPERS (ABSTRACTS)

Sustainability in Logistics and Supply Chain Management

Your waste is my resource - Assessment of the waste potential of food supply chains for innovative circular bioeconomy business models

Kathrin Auer[1,3], Prof. Dr. Helen Rogers[2], Prof. Dr. Björn Sven Ivens[3], Prof. Dr. Alexander Brem[4]

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Purpose of this paper:

As widely reported, food waste caused by inefficiencies inherent in food supply chains, is a huge problem for Germany (and other European countries). Among other effects, this has adverse and far-reaching consequences on the environment (Auer & Rogers, 2022) (Brem & Ivens, 2013). Simultaneously, food waste is also a growing opportunity for countries to satisfy their needs for sustainable energy (Jeevahan, 2021), to create new products in the context of a circular or bioeconomy (Santagata, Ripa, Genovese, & Ulgiati, 2021) (Mak, Xiong, & Tsang, 2020) (Sharma, et al., 2021) or even to create new up- or downcycled food and materials from this resource (Aschemann-Witzel, et al., 2023). In the wake of the uncertainties resulting from the Russian-Ukrainian conflict, a renewed focus has been placed on energy and materials like biopolymers, packaging, textiles, cosmetics, construction material, fuels, fertilizers and chemicals created from (regional) food waste instead of mineral oil and gas as a way to mitigate dependencies. To illustrate the potential scope, in 2021, 34% of Germany's oil supplies, 55% of Germany's gas supplies, and 26% of the country's coal supplies were imported from Russia (Bachmann, et al., 2022). Still, many industries in Europe, such as chemicals, cosmetics, transport sector and heating are still dependent on mineral oil and gas imports from countries outside the European Union (Schmid, Hadwiger, & Wilke, 2019). Food waste, the food products, the materials and the energy derived thereof represent a considerable opportunity for Western European countries to gain more economic and political independence and also to produce regional, sustainable products and energy.

In this explanatory research, the authors map food waste processes in the DACH-area (Germany, Austria and Switzerland) end to end along their respective supply chains, covering the B2B parts of the food supply chain, i.e. all parts of the food supply chain prior to the end consumer. The authors examine this from the perspective of key stakeholders including agriculture, food logistics, food processors, food wholesale and retail, restaurants, hotels and food disposal companies, both qualitative and quantitative methods. To achieve this, over 27,000 companies in Germany, Austria and Switzerland were contacted. In total over 1.300 of them responded to the survey, with 358 of these fully completing it. The characteristics of food waste from the respective perspective of each stage all the supply chain were then compared to find similarities and differences in food waste attributes. The most relevant factors for future use scenarios were then defined. This knowledge will subsequently be used as a basis to create business models for new, greener supply chain configurations and also address the role that facilitators play in their creation.

Design/methodology/approach:

Our study was explorative and both qualitative and quantitative in nature, and considered mostly primary data (surveys and interviews with key SC stakeholders in the countries Germany, Austria, and Switzerland. All parts of the supply chain from farm to fork, except from private households, have been taken into consideration.

Findings:

Our study proposes a conceptual framework on how to create new circular and bioeconomic value chains and innovative business models deriving from food waste. It depicts potential new value streams for different kinds of food waste and their distinct qualities. Furthermore, it is the first thorough survey in Western European countries depicting the kinds, amounts and frequencies of existing food waste in Germany, Austria and Switzerland in detail.

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.

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How to manage plastic waste realistically? The case of single-use packaging in the fast-food industry in Semarang (Indonesia)

Harold Krikke[1], Budi Widianarko[2], Ansje Löhr[1]
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Purpose of this paper:
Globally, Indonesia is the second largest generator of mismanaged plastic waste. One of the main contributors to the problem is packaging waste of fast food restaurants (Geyer et al., 2017).
For both local and international fast food chains chain, between 30-100% of the restaurants in Semarang were included in the research representing a sample of half the locations of all food chains in Semarang. Subsequently, five possible solutions, taken from the 10R circularity model, are discussed (Cramer, 2017).

Design/methodology/approach:
The packaging waste of twelve fast food chains in Semarang (Java) was researched and its environmental impact assessed by using a variety of footprint methodologies. Data was collected by on-site observations, assessing the amount of waste per customer. Google was used to collect data on number of customers present per hour per location. This data was entered in foot printing tools, varying from carbon footprint to a full LCA. For pros and cons of different methods see Krikke (2011).

Findings:
It was found that – although not theoretically optimal - the options 'recycling' and 'waste-to-energy' (recovery) are most realistic in Semarang today. Also, it was found that collection systems should be improved and volumes of unmanaged waste should be minimized. 'Reduce' is not significant but may create awareness amongst consumers. 'Renew' may contribute to recycling by changing material composition of the packaging. 'Reuse' and 'biodegradable' are not recommended as cleaning causes high footprints and degradation only works under ideal weather circumstances and may take decades.

Value:
This paper presents a realistic, evidence based mix of '"R" options in which environmental impacts of packaging waste are minimized in the fast food sector in the city of Semarang, Indonesia. We analyse the environmental impacts by (simplified) LCA across the life cycle of single - and multi-use packaging applying reuse, recycling or waste-to-energy. Also we look at a reduction scenario (no straws or less cutlery, containers, bottles, etcetera) as well as renew.

Research limitations/implications (if applicable):
The research is primarily quantitative. Initially we aimed for a mixed method approach in the sense that we applied different foot printing methods. This might be reconsidered. Issues for further research include obtaining better data on packaging plastics, exploring options to improve collection and to avoid competition between recycling and waste-to-energy.

Practical implications (if applicable):
As recycling and incineration are seen as the most realistic R options, it was advised to the authorities to beef up the capacity of both facilities. The recycling facility is relatively new and struggling with start-up problems. Also collection system should be improved, in particular the coverage i.e. the percentage of population that has access to the system.

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Exploring the dynamic capabilities of non-profit organizations in reverse clothing supply chains

Kanchana Dissanayake, Rudrajeet Pal
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Purpose:
Non-profit organizations (NPOs) that manage used clothing reverse supply chains are under more pressure than ever due to the changing landscape caused by the entrance of many for-profit actors, increasing competition for collection and sales, and the launch of import bans (Farahani *et al.*, 2022). NPOs face considerable challenges when compared to for-profit actors, mainly due to their extensive social responsibility and resource constraints (Hull and Lio, 2006). With the changes imposed by the external environment, the extent to which NPOs' ability to overcome challenges and grasp new opportunities are largely depending on their dynamic capabilities (DCs) to adapt to new situations (da Costa *et al.*, 2020). This study examines dynamic capabilities that contribute to the performance and survival of an NPO that collects and sells used clothes.

Design/methodology/approach:
A single-case (embedded) study is selected as appropriate for exploring the DCs of the NPO in adapting to the changing environment. The selected NPO has undergone a substantial rearrangement of its supply chain operations in response to the turbulent environment, which makes it a suitable case. The NPO supplies sorted used clothes to two other NPOs, which are considered as strategic sub-units in this case. The main instrument of data collection was semi-structured interviews to analyse the DCs of the selected NPO based on three dimensions: sensing, seizing, and reconfiguration capabilities. Supplementary data were gathered from field visits, observations, and published documents.

Findings:
Preliminary analysis shows that the NPO sensed increasing market competition and opportunities to overcome market and operational challenges. Subsequently, seizing and configuring capabilities were employed realise opportunities through stakeholder collaboration, process optimisation strategies, and invest in technology. However, resistance to change, lack of human resources, and workplace routines become the major barriers in seizing and reconfiguring the sensed opportunities. Initial results also suggest that untapped reconfiguring capabilities such as supply chain collaboration and new partnerships could play an important role in responding to changing environment. Based on the findings, the study intends to develop a framework for NPOs' success through the lens of dynamic capabilities, which enables NPOs to cultivate and harness their dynamic capabilities in a turbulent environment.

Value:
This study adds to the scant research examining DCs in the context of NPOs that engage in reverse clothing supply chain operations.

Research limitations/implications:
We contribute to the theoretical and empirical advances in the management of reverse supply chain operations in the context of NPO and bring novel insights into the DCs research. The study poses limitations in generalising findings due to the sample being restricted to a single case. Thus, more studies of the same phenomenon would be beneficial.

Practical implications:
This study sought to contribute to the management practice of NPOs as the developed framework will provide a guideline for NPOs to recognise their current practices involving DCs and identify areas for improvement.

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Circular Economy in fashion industry and the concept of "Re-Use": Analysis of consumers' consumption behaviour concerning secondhand clothes in Germany

Birgit Gampl, Philipp Hartmann
THWS - Technical University of Applied Sciences Würzburg-Schweinfurt, Germany

Purpose of this paper:
The apparel production has nearly doubled within the last 15 years (Saccani et al. 2023). This is also due to the fast fashion trend: The total number of clothes bought keeps rising while the time of usage of the single pieces drops. According to Wren (2022) in 2018 half of the Greenhouse Gas Emissions within the apparel industry was created by fast fashion. There are several studies and literature reviews about sustainable supply chain management in the textile industry focusing on institutional questions (Warasthe et al. 2022, Saccani et al. 2023, Wren 2022). However, when talking about circular economy (and the idea of "reduce, reuse and recycle") it is also important to understand the consumers' attitudes and actual behaviour towards the topic "reuse".

Design/methodology/approach:
A consumer survey was conducted from 10.11.2022 to 24.11.2022 in Germany, with 259 valid answers. Participants were asked about their attitudes towards environmental topics and about the actual number of T-Shirts, jumpers, trousers, and jackets bought last year - and how many of these pieces have been second hand.

Findings:
We found that men and women have different buying habits. Looking at these four categories of clothes (T-Shirts, jumpers, trousers, and jackets) men state that they bought on average 10.3 pieces last year (of which 1,0 pieces were second hand) and women bought 12.0 pieces last year (of which 3,8 pieces were second hand). Nearly 1/3 of women's clothes have been secondhand clothes. This share is even higher when looking at the 18 -19 years old: a bit more than 50% are second hand clothes.

Value:
This paper delivers a better understanding of the influence of gender and age on use of second hand clothes.

Research limitations/implications (if applicable):
An important limitation is asking about the number of total clothes bought within a certain time period will always lead to distortions. However, observing the real buying behaviour of such a high number of people throughout a whole year wouldn't be possible at reasonable effort.
A second limitation is the focus on only four categories of clothes: T-Shirts, jumpers, trousers, and jackets. However, we tried to focus on clothes that were as gender- and age-neutral as possible.

Practical implications:
Considering these results companies can target consumption groups in a more adequate way, e.g. inspiring elderly customers or men to start buying second hand.

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Dynamic capabilities for improved value creation in circular supply chain partnerships

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Purpose of this paper:
External partnerships and collaboration along reverse supply chains is a key element for successful transition from linear to circular economy practices (Dahlbo et al., 2017; Pal & Sandberg, 2017). The alignment and joint logistics and supply chain operations in these partnerships play an essential role for value creation, and there is accordingly a need to foster and develop dynamic capabilities that can continuously develop these operations. The purpose of this research is to explore the dynamic capabilities required for long term value creation in circular supply chain partnerships.

Design/methodology/approach:
The research is based on a case study of a dyadic partnership between a global fashion retailer and an online platform company selling second-hand apparels via multiple marketing channels in a number of European markets. In order to improve value creation, an essential ingredient in the partnership is the sharing and exploitation of knowledge and joint logistics and supply chain resources. The scope of the study covers both the retailer's and the platform company's dynamic capabilities to shape these resources. As a theoretical lens, Teece's (2007) framework of sensing, seizing and reconfiguring capabilities is applied. The rapidly changing circular practices in the fashion industry here represents an information-rich context where dynamic capabilities inherent in a circular supply chain partnership can be further explored.

Findings:
Tentative findings indicate that the partnership has enabled a variety of new circular material flows and sales channels across company borders that improves overall economic as well as environmental value creation. For instance, the global fashion retailer provides the necessary logistics muscles for an expansion of the platform company into new markets. Overall, capabilities related to sensing as well as seizing of new business opportunities are strengthened by the partnership.

Value:
This research offers new insights for how logistics and supply chain operations contribute to value creation in a circular supply chain partnership. In particular, the research provides new knowledge on the dynamic capabilities required to develop and update these operations.

Research limitations/implications (if applicable):
The research is limited to the circular practices in the Swedish and European fashion industry.

Practical implications (if applicable):
The effective and efficient design of circular supply chains is vital for improving value creation. Ultimately, this research provides guidelines for how to develop and exploit logistics and supply chain resources in a circular partnership context.

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Processed seafood sustainability supply chain management practices: A comparison of community enterprises and SMEs

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Purpose of this paper:

Due to global population growth, the demand and value of food has become one of the main interests for various groups, from governments to local groups of people. Customers are more careful about the origin of their food, the production methods and whether their food has an eco-friendly footprint. As a result, sustainable supply chain management (SSCM) is now regarded as a very important issue that enables the supply chain to operate with long-term aims (Carter et al., 2020). In terms of food, SSCM practices, including social responsibility and environmental management, bring benefits to food safety and quality, leading to sustainable performance (Kuwornu et al., 2023). Previous research has indicated that an adaptation of SCCM practices in Thai food companies is still at the early stage (Kuwornu et al., 2023). Hence, previous studies on SSCM have been less concerned with small and medium enterprises, (SMEs) since their development has been obstructed by limited resources, flexible market responses and low-risk tolerance (Yang and Wang, 2023).

Therefore, the purpose of this study is to empirically investigate current SSCM practices in the management of the processed seafood supply chain, examining two different sized enterprises, one a community enterprise and the other an SME, by using the supply chain operations reference model (SCOR Model). Our research question can be identified as "What are the differences between the processed seafood SSCM practices of community enterprises and SMEs?"

Design/methodology/approach:

A conceptual framework and associated hypotheses were developed. A survey was utilised for data collection from processed seafood producers. Descriptive statistics, a normality test and test statistics (both parametric and nonparametric) were used to compare the mean difference between two groups of processed food producers in terms of planning, sourcing, production, and delivery. Finally, semi-structured interviews were used to explore a greater understanding of SCM practices.

Findings:

The results indicated that SMEs have a significantly higher potential than community enterprises in terms of production planning, sourcing, production and delivery. Semi-structured interviews highlighted issues such as a lack of knowledge of how to achieve sustainable benefits, a lack of technology use, and the instability of raw materials from the sea, related to weather conditions, leading to difficulties in terms of production planning and sourcing.

Value:

Our study provides a better understanding of the current state of SSCM practices in processed seafood production, especially in community enterprises and SMEs. The results of this study can be used to reflect the current status of SSCM practices. Therefore, the findings should assist both community enterprises and SMES to implement more efficient processes, leading to higher performance.

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Exploring the Role of Sustainable Development Goals (SDG) in the Sustainable Supply Chain Management: Evidence from Thai Specialty Coffee Supply Chain

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Purpose of this paper:
This paper aims to explore the role of Sustainable Development Goals (SDG) in managing the supply chain toward sustainability. Since SDG has been initiated in 2015 by the United Nations (UN). UN and member countries have been trying to encourage businesses to employ SDG in business operations throughout the supply chain such as ESG (Environment, Social, and Governance) initiatives. Since then, most businesses are still struggling to balance SDG, and ESG with their profit target and other business goals (Agrawal et al, 2022). However, there are some businesses and supply chains that succeeded in implementing sustainable practices in their firms and supply chain. This paper aims to explore the reasons why and the embedded mechanism that drives a successful SDG-oriented sustainable supply chain.

Design/methodology/approach:
We choose to explore specialty coffee in Thailand as agri-food supply chain (Agnusdei and Coluccia, 2022), due to its focus on sustainability by nature. Thailand used to be our context due to our access to the key stakeholder and emerging industry of specialty coffee that can see the rise of prices and increasing demand from the domestic and international markets. We employed multiple case study methods to investigate different cases of specialty coffee supply chains that aim for sustainable practices. Seven cases were selected based on varied criteria including experience, size, and location. Triangulation is used in data collection and analysis. We interview growers, processors, and distributors across the coffee supply chain.

Findings:
Case study results found that SDG orientation is critical to sustainable supply chain management in the coffee supply chain but varied in terms of the importance of each aspect of SDG. We found that the planet aspect is the most important driver from the supply chain design stage. During supply chain planning and control, prosperity is the most important. The critical factor for the successful SDG orientation is partnerships for the goals between supply chain partners to develop supply chain collaboration, especially in terms of resource sharing supporting the results of Chauhan et al (2022).

Value:
We provide insight into the role of SDG in sustainable supply chain management. The value of this paper is the contribution in terms of interaction between literature related to SDG, supply chain collaboration, resource-based view as a key theory, and evidence from specialty coffee.

Research limitations/implications (if applicable):
Since we conducted case studies in specialty coffee in Thailand, results are limited in terms of generalization to other contexts.

Practical implications (if applicable):
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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How retailers liberalize and control product returns at the same time — an empirical exploration

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Purpose:

Offering opportunities for product returns to entice purchase has become a standard retailing practice. Yet, managing product returns has been one of the most resource intensive supply chain activities. While research on product returns policy abounds, how retailers design their return policies to simultaneously encourage purchase and dissuade returns have not been well understood.

This paper examines how online and omnichannel retailers navigate the tension between offering a lenient product return policy to boost sales and, at the same time, imposing stringent conditions to deter fraudulent returns.

Design/methodology/approach:

We drew on the paradox theory, which argues that organizations need to engage, and navigate tensions rather than resolve them, as our theoretical lens to examine how omnichannel and online retailers navigate the dualism of their product return policies.

Our data came from the product return policies of 121 omnichannel retailers and 165 online retailers, which we extracted from their websites between January 2021 and June 2021. We content analyzed the terms and conditions stated in those product return policies along five key dimensions to develop mutually exclusive coding categories within each: return policy (9 categories), return cost responsibilities (6 categories), point of return (4 categories), return period (8 categories), and exchange possibility (3 categories). Following the coding, we separately cluster analyzed the 121 omnichannel retailers and 165 online retailers using SPSS two-step clustering procedure based on the five dimensions.

The two-step cluster analysis uncovered five unique return policy configurations (RPCs) — three among omnichannel retailers and two from online retailers. We next conducted two separate discriminant analyses —one on the three omnichannel retailers' RPCs and the second on the two online retailers' RPCs — to determine how the RPCs of the two groups of retailers are differentiated by their product range, characterized by value (denoted as High- and Low-price goods), weight, size, and fragility.

We adopted an inductive approach to interpret the results of the cluster analysis and discriminant analysis to build theory, producing five archetypes of product return strategies.

Findings:

Our results show that the five RPCs are each associated with a product return management strategy, which we label as follows:

- Managing leniency with ambiguity
- Monitoring leniency with uncertainty
- Offering leniency with responsibility
- Controlling leniency with restriction
- Manipulating leniency with reasoning

We formulated five research propositions and discuss the implications of our findings for both research and retail practice.

Value:
Our five empirically grounded RPCs offer exemplar policy options to support the building of analytical product returns management models for testing and evaluation.

Research limitations:
We do not have the data to ascertain the relative efficacies of the five RPCS in terms of enticing purchase and discouraging fraudulent returns. Research into the efficacy of these product return management strategies under different cultural contexts would be a fruitful extension of this study.

Practical implications:
With omnichannel and online retailing growing exponentially, retailers' dilemma of managing fraudulent returns is not expected to relent. The product return management strategies uncovered offer valuable insights on how different product return policies could be crafted according to the characteristics of the products retailed to entice purchase and discourage returns concurrently.

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Modelling the distribution of reusable containers for cold chain products: an exploratory study

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Purpose of this paper:

The logistics industry is under enormous pressure when delivering time-sensitive products in time of uncertainty and to simultaneously reduce transport emissions. As part of their sustainability agenda, companies aim to minimise waste and extend product life through reuse meaning that many pharmaceutical and food products with temperature-sensitive characteristics need cold chain solutions to prevent their spoilage. Disposable and reusable packaging containers play an important role in the reduction of waste, virgin packaging and lowering CO_{2e} emissions (Glock 2017, Mahmoudi and Parviziomran 2020, Zhang et al., 2022).

In this research, Tower Cold Chain Solutions is the focal company, which rents reusable containers worldwide to the pharmaceutical industry for temperature-controlled products. The purpose of this study is to develop a model to analyse existing distribution flows to optimise total costs that include transportation, storage and operational.

Design/methodology/approach:

A mathematical model is formulated to optimise the total costs of containers movement and storage. It includes forward logistics costs from hubs to clients, reverse logistics costs from clients to hubs, movement costs between hubs, inventory costs and operational costs at hubs. The various constraints such as supply, demand, capacity and inventory balance are considered. The proposed model is solved using empirical data from the company's database and interviews with global supply chain and operations managers. CPLEX is used to solve the model.

Findings:

Initial findings indicate that Tower can reduce logistics, inventory and operational costs while ensuring products are delivered on time and maintaining optimal inventories with the help of the proposed model. These suggest different implications for making informed decisions about movement, storage and return of reusable containers.

Value:

This research is among the first to model flows for a network that uses reusable containers in a non-traditional setting using multi-modal transportation. The research supports Tower's strategies related to global network optimisation, operational excellence and process digitalisation.

Research limitations/implications (if applicable):

An exploratory model is limited to selected locations, stocks and flows related to the distribution of reusable containers and the next step will be to extend the model formulation and include multiple objectives.

Practical implications (if applicable):

The study will help the actors involved in the distribution of temperature-sensitive products to identify optimised flows and stock. The generalised nature of the proposed model will also help to address similar challenges in other sectors such as in the food cold chain to support the reduction of food transit losses and to decarbonise the transportation sector.

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Fab Labs and Makerspaces: Enablers of circularity in supply chains, or just going round in circles?

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Purpose of this paper:
Fab Labs and Makerspaces are well-established concepts within the creator community, providing opportunities for individuals and organizations to explore, design, and make products for themselves. Often co-located with educational providers such as schools, libraries, or universities, these facilities are typically associated with innovation and experimentation, though recently attention has turned to their sustainability credentials (Kohtala and Hyysalo, 2015; Prendeville et al., 2017). In this paper we provide the first detailed review of Fab Labs and Makerspaces in the Circular Economy from a supply chain perspective, emphasizing the critical role of supply chain management in enabling sustainable practices.

Design/methodology/approach:
A systematic literature review was conducted to identify the extent to which Fab Labs and Makerspaces have been considered in terms of the ten Circular Economy 'R-strategies' (Potting et al., 2017). From this detailed review of the literature we examine how supply chains are affected by the uptake of these facilities, structuring this around the functions of Supply Chain Operations Reference model. Based on the findings of this review a detailed agenda for future research is developed.

Findings:
Whilst Fab Labs and Makerspaces have been extensively adopted worldwide overall there has been a very narrow consideration of their contribution to the Circular Economy, focusing mainly on opportunities for recycling and repair. The management of Fab Lab and Makerspace supply chains for circularity has received little treatment in literature, with emphasis typically emphasizing the internal supply chain of the facility. As a result, we show the potential contribution of Fab Labs and Makerspaces to the Circular Economy is significantly constrained, and develop a detailed research agenda for future research to provide redress for this situation.

Value:
This is the first paper to provide a detailed exploration of Fab Labs and Makerspaces in the Circular Economy from a supply chain perspective. For research, our contribution is to provide a rigorous review of the literature, highlighting the key omissions from current knowledge and offering an agenda for future investigation. For operators and users of these facilities this paper highlights some of the key opportunities to improve circularity of their offerings by consideration of a wide range of R-strategies and improvements to the management of supply chains.

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Weak spots in the dairy supply chain and remedies: A research framework and propositions

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Purpose:
Upstream milk supply chain in the UK comprising of small and medium-sized (SM) suppliers and either larger milk processing or retailing firms is having challenges to ensure collective traceability. Several studies in the past have looked upon traceability concerns in the milk supply chain and explained, in general, the best practices and standards to ensure traceability. However, in reality, the literature did not discuss the effective ways to weave the usage of traceability tools between the SM firms and big retailers**.** Thus, the weak spots that are prevalent in the SMEs' operations are eclipsed by the powerful retailers and there is a shortage of studies to explain the effective use of a collaborative approach in the upstream supply chain. Therefore, the study aims to uncover the incompatibility traceability issues between small and large firms in the UK upstream milk supply chain. The study proposes a framework and research propositions to deal with the challenges identified in the upstream supply chain.

Design/methodology/approach:
An inductive approach was chosen for the study since the study assumed no pre-existing relationship between the interested factors such as a firm's size and traceability (Liu, 2016). A grounded theory research strategy was followed for the research, considering the possibility of emergence of a theory from aspects like social relationships, interactions, and behaviours (Noble and Mitchell, 2016). Qualitative study was chosen as the research methodology for this research and was facilitated by conducting ten semi-structured interviews of either the owners of the farms or their family members, who had a deep understanding of the entire supply chain. Since inductive thematic saturation appeared to have been reached after the first 8 interviews, the research was further extended to two more firms to confirm the inference, resulting in a total of 10 interviews (Saunders et al., 2017). The data collection for the research was mainly targeted at the owners of family-owned dairy farms within the Greater Manchester area, as the farms were the first possible source of contamination. Transcription, coding, and analysis of the interviews were done using NVivo. The simultaneous data collection and analysis, which is a feature of the grounded theory, helped in structuring the successive interviews, based on the insights gathered from the previous interviews (Noble and Mitchell, 2016). The rationale for focusing specifically on SMEs for the study was that the challenges to collaborate with the downstream members were unique for every firm, depending on their level of technological advancement. The traceability practices varied largely between one firm and the other, some already being technologically advanced, while some still being dependent on paper-based reports for traceability.

Findings:
One of the key interpretations from this research was that, despite the high importance to traceability given by the small dairy firms, the sustenance of traceability in future is possible only through strategic collaborations with the downstream members. The main inferences from the propositions established were that dispersion, processing and sourcing from multiple farms were the major weak spots influencing the traceability of milk. As an outcome of this research, it can be implied that, traceability and collaboration complement each other, or in other words, the realization of better traceability lies in qualities such as transparency, trust, and collaboration. Additionally, this study also provides empirical evidence that there are challenge for achieving collaborative traceability because of the difference in tools used by the organizations. One of the key drivers for this was found to be the unwillingness of suppliers to customize their traceability practices for just one of their customers.

Contributions:
Theoretically, the research carried out differed from the existing literature in two aspects. Firstly, though the previous research works have addressed traceability with respect to the individual firms, only very

few have focused on factors such as the loss of valuable traceability data and the possibility of weak spots being ignored when a supplier who is an SME, sells to bigger downstream members. Secondly, the aspect of decision-making power being vested with the bigger players in the supply chain, and the impact it has on hiding the weak spots within the smaller supplier firm was also studied. While the impact of the factors such as information sharing and collaboration on supply chain performance was already addressed by Wu, Chuang and Hsu (2014), this study clearly exposes how these factors influence traceability.

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Dynamics of co-operation and competition in district heating supply chains: A research agenda for energy transition

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Purpose of this paper:

Decarbonisation of the Heat and Building Sector is a major priority amongst European governments, because of its significant contribution to greenhouse gas (GHG) emissions. In UK, the government is investing significantly in a range of sustainable technologies including heat pumps, district heating (DH), hydrogen and bioenergy to accomplish its net-zero target by 2050 (BEIS, 2021). These niche technologies play complementary and competing roles amongst themselves and with incumbents along the energy supply chain (SC), from generation all the way to consumption. However, an understanding of the complex interaction between SC stakeholders, who own and control these technologies is lacking (Marcon *et al.*, 2022). An understanding of these complex interactions is important to define guidelines for competition and co-operation between respective SC entities to facilitate energy transition initiatives in the UK and beyond. By using a competitive dynamics framework (Chen and Miller, 2015), this paper explores the DH SC to identify interfaces of competition and cooperation between SC entities to develop a research agenda for green energy transition.

Design/methodology/approach:

We conducted a systematic literature review on DH management articles extracted from the Scopus database, using strings prescribed by the competitive dynamics framework. Our query yielded 113 articles, which were trimmed down to 41 articles using two levels of elimination and exclusion criteria. These 41 articles were coded and further analysed in NVivo Pro 12, using the competitiveness dynamics framework to develop themes and a research agenda for energy transition.

Findings:

The research found several boundaries where new and established technologies interact through competitive and cooperative means, both within and beyond these boundaries. These boundaries, which exist at the firm, SC, sectoral, niche and technological regime levels, create complex co-operative interactions between stakeholders who control these technologies and are not well understood in the context of energy transitions.

Value:

By highlighting existing co-operative dynamics associated with stakeholders of emerging and incumbent technologies in the DH SC, this paper calls for a paradigm shift in approaches to explaining technological transitions which are dominated by a rivalrous orientation.

Research limitations/implications (if applicable):

This paper has defined a research agenda that opens up numerous research opportunities for exploring dynamics of co-operation at different levels of analysis.

Practical implications (if applicable):

The research opportunities created by this paper would shed insights on co-operative guidelines for technology stakeholders to support energy transition initiatives.

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Assessing the State of Sustainable Supply Chain Practices: An In-depth Review of Current Factors and Future Directions

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Purpose of this paper:
Businesses are increasingly under growing pressure to cut their use of natural resources, lessen the amount of waste they produce, and reduce their impact on the environment. Additionally, firms run the risk of being held responsible for the conduct of their supply chain partners if those acts are environmentally harmful. Hence, it has become imperative for organizations to collaborate on any sustainability related practices so as to overcome any challenges faced and augment the benefits obtained. Therefore, the objective of this study is to: review a number of highly cited publications in the domain of sustainability in supply chain, visualize the structure of knowledge, identify sustainability enablers, analyze the challenges facing sustainability, summarize sustainability benefits, highlight the facilitators that aid in sustainable practices implementation and recommend future research avenues.

Design/methodology/approach:
The study utilizes an in-depth review process to investigate sustainability in supply chain management. The research method involves conducting a thematic literature assessment of the most often referenced works that have addressed sustainability in SCM. Scopus and Google Scholar databases were used to search for relevant studies, and a total of 50 articles were included in the analysis. The research method is focused on identifying the accomplishments in the field and enlightening further study avenues.

Findings:
This research has elucidated the role that several enabling factors, such as lean principles, JIT, TQM, VMI, blockchain, IoT, big data, and a manufacturer-led decentralized system, can play in the successful application of sustainable practices. Three propositions have been developed to aid businesses in their pursuit of sustainability and competitive advantage; these propositions draw on general systems theory, the dynamic capability view, and supply chain collaboration theory. Organizations can improve their overall performance and competitiveness and get closer to sustainability if they consider the aforementioned facilitators and propositions.

Value:
The novelty and value of the above research lie in its comprehensive analysis of the enabling factors that can contribute to the successful implementation of sustainable practices in organizations. The study goes beyond a narrow focus on individual practices and technologies and instead takes a holistic approach, considering the interdependencies between various components of the system.

The research also provides three propositions that draw on different theories and frameworks to guide businesses in their pursuit of sustainability and competitive advantage. By integrating insights from general systems theory, the dynamic capability view, and supply chain collaboration theory, the study provides a rich and multi-faceted perspective on how organizations can achieve sustainable success.

Research limitations:
This study limited its analysis to 50 highly cited articles, believing that these publications can illuminate a field and provide a complete summary of research. Google Scholar and Scopus were used to define related publications, providing comprehensive coverage of academic literature and sophisticated algorithms for citation monitoring.

Practical implications:
The practical implications of the study's conclusions are significant, emphasizing the need for adopting sustainable supply chain management strategies, collaborating among the supply chain players to address COVID-19 concerns, and creating rules and regulations to encourage sustainable practices. The study also underscores the importance of investing in sustainable technology and innovation to increase

the sustainability of the supply chain. Overall, the study provides important insights for practitioners, policymakers, and managers in supply chain management.

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Globalisation of Supply Chains

Supply Chain Resilience in Africa

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Purpose of this paper :
The purpose of this paper is to present and propose a macrologistics approach to analysing and recommending interventions for improved resilience of supply chains on the African continent. Africa has a complex history with significant volatility in its social, environmental and economic spheres. The systemic impact of these factors compromises poverty reduction, food security and resilience against the backdrop of an increasingly inter-connected global risk landscape – where the impact of shocks to countries in Africa are more severe due to cascading effects. The long-term objective of this research is thus to support improved resilience on the African continent through improved macrologistics management that is embedded in and can improve local and regional socioeconomic and environmental sustainability realities.

Research Methodology :
A novel approach is applied to inform supply chain resilience (SCR) initiatives from a macrologistics perspective. Analysis provides an estimate of the current and potential real productive output and capacity within a focal country economy, namely disaggregated agriculture, mining, and manufacturing outputs, and how these are connected logistically. Disaggregated freight flows are then consolidated to reveal macrologistics realities and opportunities localised value chains. This methodology reflects a data-driven approach to analysis – even in cases where full data sets are not readily available. A classification of mainland African countries was custom-made and used to map the perceived level of resilience of countries.

Findings :
Globally, shocks appear to be increasing in frequency and severity, which intensifies their impact on vulnerable countries in Africa. Analysis surfaced weaknesses in supply chains and analysis of freight flows assisted in determining how to respond with agility when shocks do occur so that recovery options are strengthened. The report highlights the manner in which supply chains have contributed to and have been impacted by significant macro-level global shocks, risks, and disruptions to justify why effective supply chains are integral to country and regional resilience. While historic shocks are considered, this report pays express attention to recent upheavals (such as the COVID-pandemic and the war in Ukraine) that launched supply chain resilience to the forefront of government, industry and academic consciousness, requiring SCR efforts to extend beyond efficiency improvement and environmental sustainability. Within the global risk landscape, transport and logistics infrastructure vulnerability in Africa is exacerbated by Inadequate capacity resulting in transport and logistics challenges.

The detailed case studies reflect an overarching research approach of analysing economic components and their related shocks, risks, and disruptions to identify weaknesses, gaps, and opportunities related to SCR. Wherever possible, this process incorporates value and supply chain flow data from freight-flow analysis as an evidence base. Customised frameworks are applied to South Africa, Botswana, South Sudan, Ethiopia, Ghana, Morocco, and Senegal which assess their macrologistics value and supply chain flows and macrologistics production factors.

Implications :
This research process, in conjunction with the mapping of supply chains from selected case-study countries supports understanding of supply chains in Africa, leading to the development of specific strategies for improvement. The macrologistics strategy proposals for increased supply chain resilience in the analysed countries may be used to synthesise high-level improvement. recommendations to support and guide the development and implementation of vital macrologistics interventions for increased resilience across the African continent.

Value :
The value will lie in the use of recommendations, by Governments and global institutions or agencies to prioritise and direct funding, aid and policy interventions in support of logistics infrastructure development and related policy or strategy interventions.

Practical Limitations :
Detailed case studies are presented for South Sudan, Botswana and South Africa, while other countries analysed require deeper analysis and detailed supply chain mapping. Peer review of the paper is currently underway.

Identification of US-Russian Relations in the Field of Logistic – Contemporary Perspective (first phase survey conclusions)

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Purpose of this paper:
American-Russian relations fell into the specific category from the beginning. This, among other things, was due to the fact that both countries showed features of superpower foreign policy (including foreign economic tactics) and fought for dominance in different parts of the world.
The situation in mutual relations worsened in 2014, after the annexation of Crimea by Russia. Then also the so-called the Western World began to regulate economic relations with Russia by imposing sanctions. After the outbreak of the Russian-Ukrainian war in 2022, the situation changed dramatically. In connection with the recognition of Russia as the aggressor, the earlier restrictions were tightened, aiming to stop economic cooperation with Russia.
The situation in which trade barriers are intensively introduced naturally determines the functioning of supply chains and the handling of logistics processes. As a result of the gradually introduced sanctions, logistics cooperation between the United States and Russia has almost ceased (no mail exchange operations, no air connections, increasing restrictions on trade), and the situation is a subject to further changes as well.
Investigating what changed after February 24, 2022 in the space that is the basis of logistics operations seemed to the Author to be reasonable and expedient. For this reason, the primary objective of the study was to determine how Experts assess the situation and what they consider important, what determinants of shaping economic relations of these economies currently indicate.

Design/methodology/approach:
The study was launched during Fall 2022, during an internship at Davis Center for Russian and Eurasian Studies (Harvard University). It's first phase was carried out in November – December 2022.
The Delphi method was used (identified research gap; carried out using an interview questionnaire; two-stage; opinions, assessments, views are discussed in order to draw common conclusions) and 13 Experts were invited to participate in the study: 5 representatives of economic practice (Business), 6 representatives of Science & Research, 1 representative of Government Administration, 1 higher education system representative (Formally Accredited Trade Professional). And, in the territorial dimension: 10 from the US, 1 from the EU, 1 from Switzerland, and 1 without a permanent residence.
The task of the Experts was assessment of the scope and degree of the state's (US Administration) reaction to Russia's aggression against Ukraine, in the institutional and practical dimension, assessment of the methods used and their impact on the conditions of economic cooperation with Russian entities, determining logistics services.

Findings:
Experts agreed that the change in business conditions had an impact on the practical dimension of American-Russian economic cooperation. They assessed that conducting any cooperation is risky, which does not mean that this cooperation does not take place (e.g. by using the "third link" located in countries that remain active (in terms of trade) both in relations with the United States and Russia.
With regard to the assessment of the degree of responsibility of the state for the decisions taken (arbitrarily affecting the possibility of conducting economic cooperation at the business level), Experts showed different opinions as to whether the state should subsidize the profits lost as a result of the imposed trade arrangements.

Value:
While the study of international relations and their economic approach is common in the literature, subjecting a group of experts to the assessment of the issue of determinants of the functioning of

international cooperation that has a direct impact on the logistics of bilateral exchange in the conditions of dynamic geopolitical changes seems to be quite an innovative approach. According to the Author, it is particularly interesting that the research was carried out mostly with the involvement of Experts presenting *the American perspective* (10 people), to some extent only "quenched" by the perspective of Experts from other parts of the world (3 people)*.
The value of the results of the first phase seems to be the conclusions drawn from the relative convergence of assessments of representatives of economic practice and other sectors, as well as conclusions regarding how Experts assess: to what extent is the cooperation of American and Russian entities under the conditions of applicable restrictions and sanctions.

Research limitations/implications (if applicable):
Naturally, a more complete picture of the determinants of US-Russian relations for logistics, which results from the expert study, will be possible to present after the completion of the next (second) phase of the study.
Since the survey was carried out among Experts from the Western keg, it would be reasonable to examine the opinions of representatives of the other party – Experts on the Russian side. Unfortunately, internal (legal and factual) tendencies limiting the possibility of making individual assessments of decisions of state authorities and bodies in the Russian Federation mean that, at least for the time being, it does not seem possible to conduct a similar study.
An obvious limitation is also the relatively small number of Experts who took part in the survey, but it is worth emphasizing that obtaining Experts for research in the US does not have to be as simple and obvious as it may seem at first glance.

Practical implications (if applicable):
The practical reference of the research results may focus on demonstrating the need for a deeper analysis of the effects of political and administrative decisions on the functioning of markets and individual industries. While no one denies the need to respond to events taking place in the socio-economic environment, their effects often affect strictly economic activity (trade, services) and determine specific risks for business entities. The results of the study can be used to better understand the relationship between the political plane and the realities of the economic world (there is no place for "vacuum" in trade and logistics, and new conditions result in the creation of solutions for cooperation despite barriers, also in logistics).

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Supply Chain Analytics

Material stacking problem detection with Mask R-CNN for STORAGE safety

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Purpose of this paper:
Image processing technology has gained much improvement in recent years. In smart warehousing, most focus is on warehouse operations to improve efficiency and save human labors. However, in put-away, re-warehousing or picking process, after being handled by forklifts or labors, the stacking of inventory items may change its shape and balance due to deviation, compression, tilting, etc., which may jeopardize the safety of stored goods and even people working in the warehouse. If there is a system that could monitor the stacking of inventory items all the time and could alarm managers should the stacking tilts or deforms to a certain level, inventory safety could be vastly improved. This study is on smart warehouse safety problems emphasizing at goods stacking to avoid the possibility of falling or collapse through image processing via Mask R-CNN. Our experiment is limited to items that form a rectangular block on a pallet, such as wooden bars, cartons or any box-shaped items.

Design/methodology/approach STS:
Mask R-CNN is a deep learning software and can be used in a wide range of applications. In this study, we used Mask R-CNN to detect the images of stacked items to see if the stacking is stable. We took photos from a warehouse and divided them into three classes – training, validation and production. VGG Image Annotator (VIA) was used for object annotation. To detect the tilt degree of stacked items, we derived formulation from book-stacking problems and retrieved dot coordinates of square frames encompassing objects in an image from the result of Mask R-CNN for calculation.

Findings:
Because there is a limited number of photos for training, validation and production, we applied image enhancement techniques such as flipping, affinity, multiplication, etc. to increase the total number of images to avoid over-fitting during the training process. The trained Mask R-CNN network demonstrated its capability in framing objects and after retrieving the dot coordinates of the frames, it could compute the degree of tilt as a reference for block stacking alarm.

Value:
The paper presents a relatively rare study of applying deep learning techniques on images as applied to material stacking safety problems. It contributes to a special smart warehousing domain. The same technique can be applied to inventory counting and help improve labor-saving in counting and in locating items in a warehouse.

Research limitations/implications:
Due to the limited number of images and restricted angles of taking the images, Mask R-CNN may not be so capable in framing objects of special angles of images. More images with diverse angles of them should be obtained for training to improve the capability of the trained network.

Practical implications:
Successful implementation of the technology developed in this study in a warehouse monitoring system can help industries in smart detection of improper stacking to assist human in improving the accuracy of safety judgement and can also save labors in reviewing images or records of a warehouse.

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Selective use of advance demand information in spare-part inventory systems

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Introduction & background:
Inspired by real-life applications, we consider an inventory system, in which an earlier fixed information infrastructure investment makes collecting advance demand information (ADI) possible. However, monitoring, analysing, and using the ADI requires an additional monitoring cost per period. The ADI is imperfect in three ways. It is not known for sure (i) if and (ii) when the demand associated with a demand signal will be materialized, and (iii) there might be instances of demand occurrence without a demand signal in advance. Excess stock built up due to using imperfect ADI can be returned. The objective is to select items to be monitored, and also to find the optimal inventory policy for the items with and without monitoring (ADI).

We consider a relevant, widely seen problem experienced by high-tech manufacturers. Manufacturers often have the infrastructure to monitor demand for spare parts. However, monitoring data requires further effort and money, and manufacturers need to decide which parts to monitor. Our paper is unique as it is the first to address this problem in the literature.

Design, methodology and approach:
We formulate a single-item problem that minimizes the total inventory holding, replenishment, emergency penalty, and return costs for the system with and without ADI. We characterize the optimal ordering and return policy, and provide monotonicity properties for the cases with ADI and without ADI. For a special case of the problem, the optimal selection rule for items to be monitored is characterized by a closed-form result, and the optimal policy is characterized by a newsvendor ratio. We use our results to develop heuristics, each making use of different types of partial information: only demand signals, only pipeline information, and no information. We compare the performance of the heuristics against the optimal policy.

Findings and practical implications:
We analytically show that the optimal ordering and return policy for items that are monitored is a state-dependent two-sided base-stock policy. Selecting items to be monitored is not a straightforward decision, and it depends not only on the three sources of imperfections but also on demand rate, cost price, return cost, and monitoring cost. Our experiments inspired by a practical case demonstrate that our analytical results are robust for more general versions of the problem. Our heuristic that uses demand information performs well, especially in cases where using ADI has higher cost savings.

The cost savings of selective use of imperfect ADI is substantial. Savings are higher with higher demand, higher cost price, lower imperfectness and lower monitoring cost. The three sources of imperfectness are not equally important. The tardiness of the information also affects the choice of items for ADI. Low return cost increases the likelihood of selecting an item and mitigates the impact of the imperfectness. Using demand signals (even though in a heuristic way) outperforms the optimal use of pipeline information. Ignoring both partial information types completely, which is typical in practice, leads to high costs. Despite the imperfectness of ADI, the policies with ADI demonstrate the intended purpose such that the manufacturer can typically keep stock only when there is a demand signal and return the stocks in the absence of the demand signal.

Smart/Digital Logistics and Supply Chain Management

Promoting digital transformation in the Japanese logistics industry

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Purpose of the paper:
The logistics industry in Japan has been facing several issues such as long working hours and low wages, shortage of human resources due to the ageing population, low labour productivity, poor business practices and relationships with shippers, changes in demand patterns induced by e-commerce and coronavirus pandemic, high disaster vulnerability and need to respond to environmental issues such as reduction of CO2 emissions. With the goal of addressing these issues, efforts on logistics digital transformation (DX) are underway based on the "Comprehensive Logistics Policy Outline 2021" (MLIT, 2021), "Comprehensive Physical Distribution Policy (2021-2025)" (Cabinet decision, 2021), and the "Physical Internet Roadmap" (METI, 2022). Japan aims to achieve 100% digitization in the logistics sector by 2025. Although efforts towards digitization are underway, the actual proportion of businesses that are working on DX is currently about 30% only and there is still a long way to go. This study aims to identify issues and generate solutions related to the promotion and implementation of logistics DX in Japan.

Design/methodology/approach:
The study uses the focus group discussion method to structure group interactions and elicit and combine expert judgments via multiple rounds of interaction to gain an in-depth understanding of the issues facing logistics DX. We conducted several interviews with companies in both logistics and technology sectors to gather necessary information. Finally, we gathered 16 purposely selected expert members from academia, industry, and the government to conduct assessments in three instances.

Findings:
Preliminary findings of the factor analysis revealed the following issues 1) low loading efficiency, turnover rate, and utilization rate of logistics assets, 2) inability to plan and efficiently allocate logistics resources based on demand, 3) lack of information sharing and collaboration between shippers and logistics companies, 4) problems with systems and contracts (unclear content of transportation contracts, underdeveloped domestic transportation business), and 5) delay in standardization related to logistics, advertisement and systems leading to the low impact of IT investment as the main issues surrounding the promotion of logistics DX. The next stage of this study will focus on finding response strategies to address identified issues.

Value/Originality:
To the best of our knowledge, this is the first study that brings together experts from industry, academia, and the government to identify issues preventing logistics DX and generate solutions to promote logistics DX in Japan.

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Identifying Key Successful Factors for Digital Transformation in Logistics Industry

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Purpose of the paper:
Digital transformation has become a trend in many industries, with enterprises now viewing it as a necessity to survive and compete in the digital economy era. The purpose of this research is to identify key factors for the logistics industry to successfully undergo digital transformation.

Design/methodology/approach:
We adopt the Analytic Hierarchy Process (AHP) method to develop an analysis framework consisting of four constructs and 17 criteria based on a review of relevant literature. Using this framework, we designed a questionnaire and collected survey data from 11 logistics experts.

Findings:
The AHP results reveal that logistics enterprises need to "create the value of change" and achieve disruptive innovation for successful digital transformation. Among the 17 criteria identified, the most important is the determination of enterprise leaders to undergo digital transformation. Enterprises must comprehensively execute digital transformation from top to bottom, providing clear goals and strategies to ensure employees fully support the transformation. Financial resources are also crucial for successful transformation. Enterprises should evaluate whether they have sufficient resources and abilities to bear risks and proceed step-by-step to increase employee acceptance.

Value/Originality:
Logistics experts suggest that enterprises should focus on "transformation" rather than just "digital technology." We hope that these analysis results can serve as a reference for logistics enterprises to develop and execute strategies for digital transformation in the near future.

Technologies for designing a Digital Twin and Artificial Intelligence technology-based Decision Support System in transportation and sustainability: a Literature Review

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Introduction:

As shown in recent natural disasters and adverse weather conditions, the planet experiences devastating effects of the climate change, incl. the loss in biodiversity and increase of global catastrophes (World Health Organisation 2015). In many ways, climate change and modern transportation go hand in hand (World Health Organisation 2021). Regulations that protect the diverse organisms and vulnerable systems and reduce human-made pollution, for example traffic-caused emissions, need to be adjusted to act more sustainable. To help stakeholders in politics and government to set and reach goals to accomplish sustainability and create an even more ecologically sustainable regions, an "Alpine Twin" should be developed. "Alpine Twin" is a Decision Support System (DSS) for enabling better and faster decision making and insightful choices based on data.

Purpose of this paper:

The purpose of this scholarly paper at hand is to investigate into the current state of technology which can be used to develop a Digital Twin and Artificial Intelligence technology-based Decision Support System in transportation and sustainability. The aim of this paper is to review the literature on the technologies, which can be used in a later implementation of the Decision Support System. Thereby concepts and categories are extracted that provide a solid basis for further discussion and future elaboration on the design and development of the Decision Support System.

Design / methodology / approach:

This research makes use of the Grounded Theory Methodology (GTM). GTM supports to create a more complete understanding of how a Decision Support System can be designed, what it can consist of and what should be considered while doing so (Walsh et al. 2015).

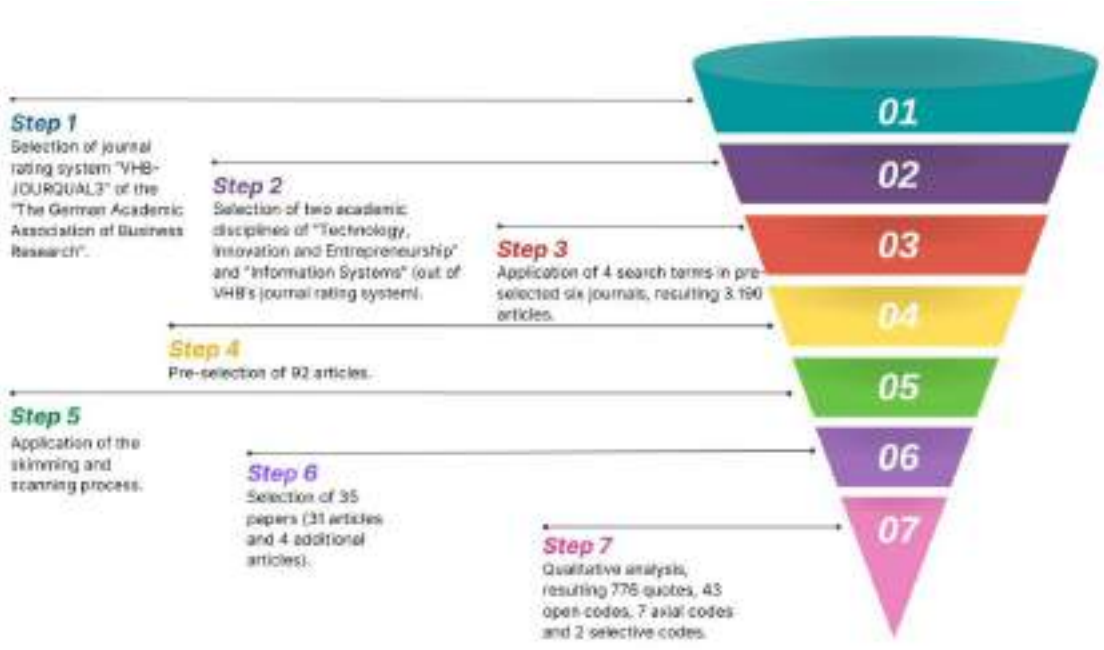

Figure 1: Literature research process

As depicted in figure 1, a narrative literature research on existing Digital Twin and Artificial Intelligence technology-based Decision Support Systems is conducted. Therefore, the journal rating system "VHB-JOURQUAL3" of the "The German Academic Association of Business Research" was chosen as the starting base for data collection and two academic disciplines of "Technology, Innovation and Entrepreneurship" and "Information Systems" (out of VHB's journal rating system) have been selected as source for journal search and selection. Four search terms were defined and queried in six journals. The total number of results from all six journals amounts to 3.190 articles. From this amount the most relevant articles were selected. In total 92 articles have passed for further investigation. In further consequence, the pre-selected articles experienced a rigorous skimming and scanning process. In total 35 papers (31 articles and 4 additional articles) passed this process and have been chosen for the systematic literature review. The articles were reviewed based on the applications of different algorithms in different areas of the DSS and whether these are suitable to the research context.

The selected papers were then examined for quotations, the final amount of which results in 776. These quotes are then labelled with 43 open codes. These codes are grouped into 7 axial codes and show the connections between the open codes. These categories are then connected around two core categories which represent selective codes.

Findings and practical implications:
Within the scope of work, a framework for the structure and design of the DSS is developed. It describes how a DSS can look like and which techniques it can implement.

The findings should indicate that if industries, governments, and societies were to implement recommendations based on the simulations and predictions of the Environmental Digital Twin, they could meet sustainability goals such as "Climate Action Plan 2.0 – Transport" (Convention Alpine 2023) and "Climate neutral economy by 2050" (European Commission 2018) more easily or even faster.

Through this literature review an overview on the topic of DSS in the context of sustainability and transportation has been made. Furthermore, this literature review provides recommendations to those who are going to develop the Digital Twin and Artificial Intelligence technology-based Decision Support System in transportation and sustainability for stakeholders in politics and government. This is going to make the project work on the Decision Support System much more accurate, easier, and more transparent.

Acknowledgements:
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Effectiveness of Artificial Intelligence (AI) Systems as an Advisory Platform for the Small and Medium-Sized Manufacturing Enterprises (SME): An Experimental Approach

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Purpose:
In the past few years, the advancements of Robo-advisors in the field of financial management have presented a novel approach for decision-making (D. Blanche, et al, 2019). Similarly, and within the framework of Industry 4.0, AI-based Chatbots have provided predictive analysis for decisions related to the Manufacturing Execution Systems (MES), (S.Mantravadi, 2020).
A recent article has evaluated the effectiveness of human-Chatbot interaction in terms of efficiency and quality of the advice received from four different AI-based chatbots. Comparing the results of this methodology versus a crowd-sourcing approach seeking advice for knowledge-based questions revealed a higher level of efficiency by the AI-based advising system. However, the quality of the advice would need improvements (Z. Gao, J. Jiang, 2021).
The objective of our research is to investigate the efficiency and value of ChatGPT, a highly promising and newly available natural language AI-based system, to facilitate the decision-making for SME companies that either may be just a start-up entity or are in the midst of diversification of their products and services. Our exploratory attempts have revealed highly valuable advisory responses from ChatGPT. For example, the inquiry to seek advice on how to select suppliers for a particular small manufacturing firm resulted in close agreement with the existing body of knowledge in the field of supplier selection. Another inquiry was on the negative aspects of significantly reducing the takt time for a generic production line. It was impressive, and operationally accurate, to receive the responses that the quality of production would decrease and the stress level of operators may increase.

Design/methodology/approach:
We are gathering quantitative and qualitative responses from ChatGPT on a number of inquiries related to the strategic, tactical, and operational aspects of the SME entities. We shall evaluate the obtained feedback from ChatGPT by making comparisons with the existing body of literature, as well as feedback from our industry affiliates.

Value:
If indeed we find positive and value-added results from our inquiries through ChatGPT, the SME community may benefit accordingly with their own ChatGPT-based inquiries, especially for new as well as high-risk business decision analysis.

Research limitations/Implications:
Depending upon the type of questions and inquiries posed to ChatGPT, the SME client must ask well-defined and rather pointed questions, otherwise the quality of response(s) may not be of any value. Furthermore, a series of related sequential and parallel questions should be posed to indeed receive a value-added advice. The SME practitioner should consult with a human expert/consultant the authenticity and business-worthy aspects of the responses provided by ChatGPT.

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Artificial Intelligence in Demand Planning for Supply Chains – a Systematic Literature Review and Case Studies

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Purpose of the paper:
Demand planning is perceived as one of the main functions of the supply chain to create value and improve supply chain performance. The last decade has seen the emergence of artificial intelligence (AI) in demand planning. The objective of this work is to conduct a systematic literature review of the current body of knowledge on the use of AI in demand planning in supply chains and suggest a conceptual model for application in real-world supply chains.

Design/methodology/approach:
In this study, a three-stage systematic literature review protocol is employed. Four sets of search terms which include demand planning, forecasting, supply chain, and artificial intelligence are used to identify a total of 104 publications. Bibliographic clustering of publication keywords is deployed to identify knowledge clusters and themes which are used to develop a conceptual model and verify its applicability using two case studies.

Findings:
Results of the analysis demonstrated that the current literature on AI in demand planning pivots around three knowledge clusters such as functional supply chain, models and algorithms, and forecasting, and 13 themes. The supply chain management theme dominates the functional supply chain cluster with 68% of all publications. The models and algorithms cluster focuses on technical aspects of AI in demand planning with models (Artificial Neural Networks, and Long Short-term Memory) and learning algorithms being the most prominent themes. Whereas the forecasting cluster covers the operational aspects with sales, cost, and decision-making as the themes. Results also show that most researchers focused on the empirical and modelling approaches to develop AI-based demand planning systems, thus providing a narrow view of the topic. An exploration of the wider implications of AI in demand planning including the role of AI talent and human trust in prediction is critical.

Value/Originality:
To the best of our knowledge, this study is the first systematic literature review of the current body of knowledge on AI applications in demand planning in supply chains. The suggested conceptual model can be used to develop propositions and empirically validate what is currently missing in the existing literature.

Research limitations/implications:
This systematic literature review is limited to publications in the English language. It has therefore potentially neglected studies conducted by scholars in other languages.

Practical implications:
Partitioners might use the proposed conceptual model to understand the required parameters and conditions for the use of AI in demand planning to add value to their supply chains. The model could also be utilised as a compass to obtain a high-level road map for starting an AI journey within a supply chain's demand planning function.

Digitalisation and Warehouse Performance: evidence from Saudi Arabia

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Purpose of this paper:
The aim of this study is to investigate the impact of warehouse digitalisation on warehouse performance in the context of Saudi Arabia.

Design/methodology/approach:
Through the extensive review of the digitalisation literature, a conceptual framework is developed with structuring, bundling, and leveraging constructs of the resource orchestration theory (ROT) as the drivers of the warehouse digitalisation that creates value and improves the warehouse performance. This study employs a quantitative methodology with data collected from 323 managers who are involved in IT deployment in Saudi Arabian warehouses. A structural equation modelling (SEM) approach is employed to evaluate the conceptual model and test the hypotheses. Furthermore, a fuzzy set qualitative comparative analysis (fsQCA) approach is applied to identify different configurations of the constructs of digitalisation. Identifying alternative ways of accomplishing digitalisation in a warehouse through fsQCA complements the SEM results.

Findings:
The SEM results indicate that all the ROT constructs are significant and positively associated with digitalisation. Structuring has a β value of 0.20 (t = 3.78), bundling has a β value of 0.52 (t =11.04), and leveraging has a β value of 0.49 (t = 6.93). All three constructs have a significance level of 0.000. Results also indicate that digitalisation has a positive effect on value creation, financial performance, and operational performance. For value creation, digitalisation has a β value of 0.11 (t = 2.12 with a significance level of 0.03). For financial performance, digitalisation has a β value of 0.37 (t = 7.18 and a significance level of 0.000). For operational performance, digitalisation has a β value of 0.50, a t-value of 10.50, and a significance level of 0.000. However, the results of this study demonstration that firm size (β = −0.08), industry type (β = −0.09), and ownership structure has no impact on digitalisation (β = −0.03).

The fsQCA results confirm that achieving high warehouse performance in Saudi Arabia depend on the configurational effects of all the model variables as opposed to individual effects. The fsQCA results reveal that the combination of structuring, digitalisation, operational performance, and financial performance has a positive impact on value creation ((configuration with very high consistency (0.944) and adequate coverage (0.567)). In addition, the combination of structuring, bundling, leveraging and digitalisation led to a high level of operational performance ((configuration with high consistency (0.952) and adequate coverage (0.629)). Moreover, the combination of structuring, digitalisation, and value creation with the absence of leveraging had high consistency (0.920) and adequate coverage (0.447) which led to a high level of financial performance.

Value:
This study extends the existing literature on digitalisation by investigating the effect of digitalisation on warehouse performance. To the best of the researcher's knowledge, this study is the first of its kind that used ROT combined with fsQCA to examine the impact of digitalisation on warehouse performance.

Research limitations/implications:
For this study data have only been collected from one country, namely Saudi Arabia. It means that the results may vary in other developing countries. The reason for this is that countries have different warehousing systems, within which the processes of digitalisation may vary significantly. Future research

may investigate the validity of the model in other developed or developing countries with warehousing systems that have different characteristics to identify any variances and seek generalisability.

Practical implications:
The study guides managers to developing a step-by-step procedure for implementing the digitalisation process in their warehouses. It also assists managers to assessing the type and level of the resources required for the digitalisation of their warehouses.

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The application of Digital twin technology in supply chain resilience and risk management

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Purpose of this paper:
Digital twin technology (DTT) refers to the creation of a virtual replica of a physical object, system, or process. It provides real-time data and insights into the performance and behavior of its physical counterpart, enabling improved monitoring, analysis, and control. Although DTT has received considerable attention in practical applications, academic understanding of it lags behind. This paper aims to investigate how DTT can be utilized in supply chains to enhance supply chain resilience and minimize potential risks and disruptions.

Methodology:
This paper adopts a systematic literature review. In total 35 articles have been identified. Multiple accounts of DTT adoptions within industry were also consulted to gain further insight.

Findings:
Our findings suggest that DTT is still in its early stages of development, but it is becoming increasingly popular within supply chains. To take full advantage of its capabilities, integration with other digital technologies is necessary. We synthesize the primary areas in which DTT can be deployed in supply chains and elucidate the mechanisms by which it facilitates risk management and enhances supply chain resilience. Additionally, we have identified the main obstacles to its wider adoption in supply chains.

Originality/Value:
This paper is one of the first studies to examine the current state of DTT adoption within supply chains. It lays a firm foundation for future research.

Practical implications:
This paper offers valuable insight for supply chain practitioners into how DTT has the potential to enhance supply chain resilience as well as a number of challenges to its successful diffusion.

Research limitation/implications:
This systematic review focuses on the adoption of DTT within supply chains, and great care was taken in selecting search terms. However, the authors acknowledge that their choice of terms may have excluded certain DTT articles from this review.

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Can Lean, Green and Artificial Intelligence (AI) be integrated for supply chains?

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Purpose of this paper:
The purpose of the research is to investigate a conceptual model that combines three distinct supply chain practices (often with trade-offs) namely, Artificial Intelligence (AI) with Lean management and Sustainability practices in the supply chain and measure the combined impact on environmental performance of the manufacturing plants.

Design/methodology/approach:
We intend to use a deductive approach for the research. First hypothesises would be deduced from the literature incorporating the relations among the variables. Based on three independent variables and one depended variable we would create four different constructs. From the constructs we would create the list of questionnaires to collect data from UK manufacturers.

We then intend to conduct a principal component analysis which is a dimension reduction technique that helps reducing the outliers in the questionnaire. We then intend to use Structural Equation Modelling (SEM) technique using SMART-PLS4.0 to investigate the individual hypothesis and to evaluate the conceptual model. Moreover, we intend to investigate if the sustainability practices mediate the relation between AI and environmental performances.

Findings:
We intend to validate the model and to report the results of hypothesis testing. We would also report the reliability and validity scores as well as the model fits in the result. This would facilitate the validation of the model.

Value:
The four distinct supply chain practices (AI, Lean, Sustainability and Environmental Performances) are discussed individually in the exiting literature. Our research would be one of the first ones to investigate all of them simultaneously and establish a mediating effect of sustainability practices between AI and environmental performance.

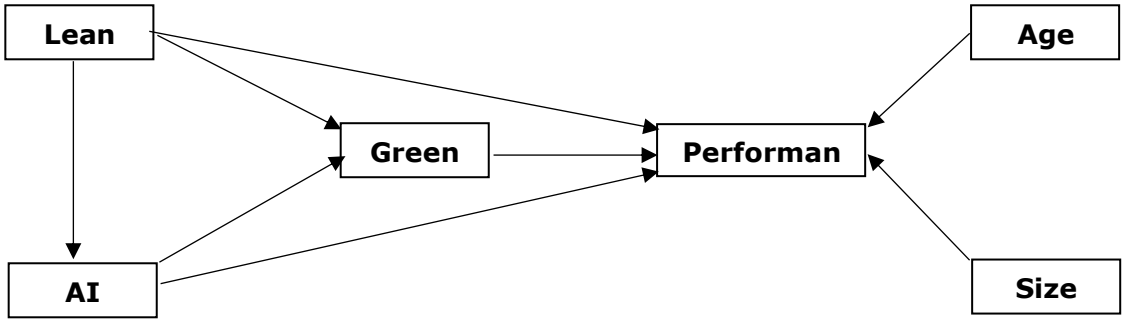

Figure: The conceptual Model

Research limitations/implications (if applicable):
Our research mainly aims at contributing to the augmentation of the exiting literature around supply chain integration and thus takes the existing knowledge to the next level.

Number of responses we would get can be a potential limitation of the study as sometimes the rate of response can be low. Further research can be done using the inductive approach to have a better insight into the interoperability among these conflicting variables.

Practical implications (if applicable):
Our research can be used as a reference point for the managers to adopt a combined model rather than pursuing these practices as separate strategy. This would eventually lead to reduction in emissions, streamline the supply chain process through lean practices and provide better efficiency through the use of artificial intelligence (AI).

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Evaluating smartness in picker-to-parts order picking: a socio-technical systems theory perspective

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Purpose of this paper:
Surveys have shown that most companies still use paper-based lists or handhelds to support picker-to-parts order picking, but more modern approaches like replacing handhelds with small wearables, Pick-by-Voice, Pick-by-Vision, or even autonomous picking robots are gaining ground. This fits into a broader development, usually tagged as "smart logistics". What constitutes "smartness" in this context, however, remains vague. This paper aims to contribute to the understanding of smartness in picker-to-parts by applying the socio-technical systems (STS) theory.

Design/methodology/approach:
The methodological approach is following a two-step process: (1) Incorporating socio-technical system (STS) theory, we identify criteria for "smart" support of picker-to-parts order picking by a systematic literature review and (2) Establish an evaluation framework as a concept map.

Findings:
Usually, technologies supporting picker-to-parts order picking are evaluated by how they improve efficiency (measured in picks per hour) and effectiveness (how good they are in reducing picking errors). This approach falls short of acknowledging that order picking is a socio-technical system. Following STS theory, smartness must include factors like cognitive load/ergonomics, immersion, contextual fit/human-machine interaction, etc.

Value:
This paper contributes to the still relatively small body of literature on smart picker-to-parts order picking by clarifying the dimensions of smartness in this field. A clearer understanding of smartness is helpful to design support devices that are better accepted by warehouse staff, without compromising picking effectiveness and efficiency or even improving performance.

Research limitations/implications:
So far, the evaluation framework is purely conceptual.

Practical implications:
The evaluation framework can be used to critically assess the technology currently used in warehouses for supporting picker-to-parts order picking as well as to inform the design of new systems.

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The impact of monetary incentives on those who work "on the clock": Empirical evidence from order picking

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Purpose of this paper:

Staying competitive in the market requires companies to provide high service levels to customers. Especially in e-commerce, this translates into the need to fulfill small orders frequently and quickly (Grosse, 2023). This trend puts pressure on order picking, which is a labour- and time-intensive logistical process (De Lombaert *et al.*, 2022). Order pickers are therefore required to collect large numbers of orders within limited time windows. However, they often have to work "on the clock" and suffer from workload peaks during the day (Vanheusden *et al.*, 2022). In light of this challenge, a common method adopted by companies is to offer monetary incentives to reward performance (Sgarbossa *et al.*, 2022; de Vries *et al.*, 2016). However, how order pickers behave under time pressure and how monetary incentives impact their performance and well-being is not yet well understood. We therefore conducted an experiment to approach this issue. Besides measuring the overall work performance, comprising productivity (number of items picked per minute) and accuracy (number of pick errors), we used eye tracking (ET), a non-intrusive technology for measuring eye movements (Zheng *et al.*, 2022), to investigate the visual behaviour of order pickers under time pressure across different monetary incentive schemes.

Design/methodology/approach:

We designed a controlled laboratory experiment to simulate a real-world order picking setting, involving university students as participants. We examined two types of time constraint settings (no time constraint vs. limited time window) and three different monetary incentives (no reward, productivity-based reward, and accuracy-based reward). We used a 2×3 between-subjects design, with time constraints and monetory incentive condition as independent factors. The dependent variable is overall work performance, measured by productivity and accuracy. We also measure visual behaviour of order pickers as a reflection of their situational arousal.

Findings:

The research is currently in progress and the data collection is expected to be finished by May 2023. We expect to find a causal relationship between time constraints and order picking performance, wherein situational arousal partially mediates the relationship and monetary incentives moderate the overall treatment effect.

Value/originality:

This paper is the first to explore how time constraints and monetary incentives impact the work performance of order pickers in an experiment. Our study also makes a first attempt to use ET to reflect behaviour changes of order pickers, providing some insights into the mediation effect of situational arousal.

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Industry 5.0 and supply chain management: current state of knowledge

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Purpose:
The last decade has seen 'Industry 4.0' driving global companies, Supply Chain (SC) practice and research towards operational excellence through responsive systems, based on flexible production and transparency. Since late 2016, scholars have been calling for a more precise declination of the intents of Industry 4.0 into the so-called 'Industry 5.0', a term introduced in 2015 (e.g., Martynov, Shavaleeva, and Zaytseva, 2019). According to the European Commission (2021), Industry 5.0 "complements the existing "Industry 4.0" approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric, and resilient industry". The Covid-19 pandemic amplified SC vulnerability, highlighted the need to strengthen resilience, and to rethink working models. SC weaknesses were further exposed by subsequent international conflicts reinforcing the need to futureproof industries and economies against external shocks.

The aim of our study is to capture the current state of knowledge on Industry 5.0 and its scope, and discuss the corresponding implications. To achieve this, we reviewed up-to-date academic, practitioner and policy making documents on Industry 5.0 to clarify the concept, its advances over Industry 4.0, and the implications for academia and practice. Our aim is to inform the debate on Industry 5.0 and its merits, and propose a relevant research agenda on the current gaps of knowledge.

Methodology:
Our study followed a systematic literature review following the guidelines of thematic analysis (e.g., Braun and Clarke, 2006). We reviewed peer-reviewed academic papers available on ABI/INFORM Global that focus on Industry 5.0 in the context of SC management.

Findings:
Industry 5.0 is an emerging concept, and currently it features as the focus of investigation in research across a variety of disciplines. Our study aimed to assess the current state of knowledge in the context of SCM. Our investigation summarises the main definitional features, and critically reviews the associated implications for SCs, e.g. typically reported opportunities and challenges. Subsequently, we summarise and propose a research agenda which should be of value to academic research attempting to further clarify the practical and strategic considerations for the transition to Industry 5.0.

Value:
The paper contributes to our understanding of the recently emerged concept of I5.0. The research gaps identified and the research agenda developed should make it relevant to academia but also to practitioners envisaging adoption of relevant practices for their organisations.

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Digitalization in Production Logistics towards to Industry5.0: Analysis of Industrial Project Cases

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Purpose of this paper:

The purpose of this study is to explore the impact of digitalization on production logistics and the skills and competencies required of future employees, by analysing industrial project cases given to students in a digitalization course. The Industry 5.0 concept builds on the Industry 4.0 paradigm and emphasizes the integration of the human factor into the production process [1], [2]. By prioritizing customer experience and promoting sustainable and resilient business models aligned with the UN's Sustainable Development Goals, this approach is gaining increasing attention in industry [3], [4].

The COVID-19 pandemic has accelerated the trend towards digitalization and automation in manufacturing, as companies seek to build more resilient supply chains and reduce reliance on manual labour [5], [6]. The implementation of digital technologies has significant implications for production logistics, offering potential benefits such as increased efficiency, reduced waste, and improved safety. However, these benefits need to be balanced against potential risks such as job displacement and data security [7]. To bridge the gap between theoretical knowledge and practical skills, engineering education often includes practical project and lab work [8], [9]. The use of industrial case studies is a commonly employed method to enhance students' understanding of the real-world application of concepts. Therefore, this study analyses the industrial project cases to gain insights into the evolving landscape of production logistics and the role of digitalization in driving sustainability and efficiency.

Through this analysis, the study aims to contribute to a better understanding of the competencies required of future employees in the Industry 5.0 era. It also aims to provide valuable insights for educators and practitioners seeking to prepare students and employees for success in the rapidly evolving field of production logistics.

Design/methodology/approach:

This study uses a case study methodology to analyse the industrial project cases given to students in a digitalization course in the Sustainable Production Development Master level program over the past four years. We collected and analysed data from the case studies to identify patterns and trends in the skills and competencies required of future employees in the Industry 5.0 era. Overall, the case study methodology allowed us to gain a deeper understanding of the impact of digitalization on production logistics and the skills and competencies required of future employees. By examining a range of industrial project cases, we were able to identify common themes and trends, which may have important implications for educators and practitioners in the field.

Findings:

Our analysis of the industrial case studies given to students showed a clear trend towards a higher focus on customer experience and product intelligence. The Industry 5.0 concept requires a more human-centric approach to production logistics, which was reflected in the case studies. Additionally, we found that these case studies also emphasized the need for employees to have a higher level of skills and competencies in areas such as data analytics. Furthermore, our analysis revealed that the integration of digital technologies in production logistics led to increased efficiency and sustainability.

Value:

This analysis of industrial case studies provides valuable insights for both educators and practitioners in the field. As Industry 5.0 continues to gain momentum, it is important for educators to ensure that their students are equipped with the necessary skills and competencies to succeed in this new era of production logistics. Likewise, practitioners can benefit from reflecting on the impact of Industry 5.0 on their businesses and the new requirements for future employees. Overall, this study contributes to a

better understanding of the evolving landscape of production logistics and the role of digitalization in driving sustainability and efficiency.

Research limitations:
This study has several limitations that should be considered. Firstly, the analysis is based on a specific course, which may limit the generalizability of the findings to other contexts. Secondly, the case study methodology used in this study may not capture the full complexity of production logistics in the concept of Industry 5.0. Finally, the study did not collect data on the long-term impact of the digitalization course on students' skills and competencies in the workplace.

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Building Resilience for Supply Chains

Design for Manufacturing and Supply: An application for Collaborative Manufacturing (COLMAN)

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Purpose of this paper:
Small and medium-sized enterprises (SMEs), particularly those operating in electronics manufacturing services (EMS), depend heavily on their customers as the customer orders are unpredictable and highly customized. Therefore, SMEs have to produce to order, making them also highly dependent on their suppliers in meeting the demand of their customers. SMEs therefore absorb majority of the uncertainty in their supply chain, and therefore, SMEs need flexibility and resilience. However, in contrast to larger enterprises, SMEs have limited influence over their supply chain,. During the Covid-19 pandemic, the global supply crisis, in particular, related to the chip crisis, now still, we have seen that this dependency and structural problems of the supply chain have deepened the problems and led to long lead times (such as 2-3 years) and this now does not seem to be reducing.

In this paper, as part of a research project on collaborative manufacturing called COLMAN, we develop a proof-of-concept demonstrator of a tool that enables SMEs in EMS to communicate alternative components/designs, including costs, availability, and lead times, with their customers preferably at an early stage of the customer order process, considering the multiple stages of the customer order process, each of which may bring constraints to design. The tool collects input from the supply chain and interacts with customers.

Design/methodology/approach:

Our problem is motivated by the needs of PCBA SME manufacturers. To address this need, we are building a proof-of-concept tool that aims to reduce lead times, reduce the costs between quoting and procurement, and increase customer responsiveness and satisfaction. In order to achieve these objectives, we are adopting a data-driven approach that involves collecting and analysing historical data on lead times and prices of PCB components.

Using machine learning algorithms such as LSTM, we aim to anticipate future prices and lead times of PCB components. Additionally, we will utilize generative AI techniques to recommend alternative parts in case of supply chain disruptions. We have chosen to use generative AI techniques for recommending alternative parts because relying on salespersons to manually search and recommend parts can lead to errors and inconsistencies. Often, salespersons rely on internet search engines to identify alternative parts, which can be time-consuming and unreliable. By using generative AI, we can train the algorithm on a datasheets and other sources of data of alternative parts and integrate it with our tool.

Finally, a user-friendly interface to integrate this with the existing systems that will enable users to easily input data and receive predictions. By adopting a data-driven approach and integrating these technologies, we aim to provide accurate and reliable information that will enable PCBA SME manufacturers to make informed decisions, reduce costs, and improve customer satisfaction.

Findings:
Our future goal is to test our tool/platform in its working environment at the manufacturer.

Value:

Our paper is one of the few papers addressing alternative components considering DFX (Pashaei sand Olhager, 2015, Tan et al., 2020, Gan et al., 2022, Chiu and Kremeer, 2011, Nepal et al, 2012). Our paper is different from those in the literature in two ways: First, we consider different stages of the

customer order process. Second, we propose proactive and reactive suggestions for alternative parts/design changes. For the proactive approach, we predict changes in lead time and price.

Research limitations/implications (if applicable):

One of our biggest challenge is to find alternative parts. This requires using tacit knowledge. This knowledge gap will be bridged by the recognition and summary features of AI-based large language models , e.g., ChatGPT. Our other challenge is to predict price and lead time changes and generate alerts if there is a significant deviation from quotations.

Practical implications (if applicable):

The problem is very relevant for SME manufacturers. The tool can contribute to supply chain integration for SMEs in EMS. Such tools can create value for customers of SMEs and they can make them a player in their market and they reduce their dependency on customers and the supply chain. Our platform is also generalizable for many other similar industries.

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Democratisation of Supply Chains: Definition, Challenges, and Future Research Agenda

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Purpose of this paper:
Manufacturing has been one of the key engines of economic growth ever since the industrial revolution. However, recent digitalisation initiatives driven by Industry 4.0 are paving the way for a more democratic, resilient, and localized manufacturing paradigm capable of adapting quickly to changing market conditions. Despite these opportunities, inflexible supply chain networks are becoming bottlenecks for this transition. Moreover, the recent COVID-19 pandemic emphasised the need for more resilient and responsive supply chains that can quickly adapt to disruption. In this context, the paper proposes the 'Democratisation of Supply Chains' as a critical area of research that needs the immediate attention of academics and industry practitioners alike and call for a closer evaluation and restructuring of supply chains. The purpose of this paper is to define and explore this concept, highlighting key characteristics and enablers, identifying the primary challenges to achieving more democratic supply chains, and finally, proposing a future research agenda with the aim of operationalising the concept.

Design/methodology/approach:
An exploratory research approach was adopted as it provides insights into new areas of research that needs further investigation. This helps in understanding the context and how to position the novel concept among other related concepts such as Industry 4.0, Cloud Manufacturing, etc. A literature review was conducted utilizing popular research databases and keywords including 'Democratisation' and 'Supply Chain' to understand the key characteristics and enablers. Drawing on related concepts 'democratisation of manufacturing', 'democratisation of data', etc. a working definition is proposed. To validate the initial findings and gain more insights, expert discussions were held in the form a hybrid workshop with over 40 participants from academia, industry and industry consultants.

Findings:
Democratisation of Supply Chains is *a process of making supply chains (SCs) more accessible, transparent, and participatory, ensuring equality in SCs for all stakeholders including the suppliers, distributors, customers, and communities, with the aim of enhancing sustainability, resilience, and trust*.

Preliminary findings and expert discussions resulted in identifying key characteristics of democratisation: Collaboration, Transparency, Decentralisation, Localisation, Customisation, Sustainability, Diversity, Resilience, and Trust. Furthermore, Digital technologies, Digital platforms, new business models, and new strategies were identified as key enablers of the concept which need more detailed exploration. The focus of the round table discussions was to carry out in-depth discussions on the primary challenges from two perspectives: academic and industry practitioner. In conclusion, key challenges include lack of trust, resistance to change, lack of policies towards standardisation, associated costs, technology adoption, and security. Finally, a ten-point research agenda is presented in order to operationalise the concept.

Value:
The study proposes a working definition, key characteristics, enablers, primary challenges, and a research agenda to operationalise the 'democratisation of supply chains' concept.

Research limitations/implications:

Future research requires more detailed studies in areas including the degree of desired democratisation (e.g., current and future status), understanding benefits, triggers, and limitations, developing strategies to building trust, including technology adoption strategies, addressing cross-cultural challenges, formulating new SC configurations, introducing standards, examining the capability of existing platforms, developing frameworks, tools, and evaluating indexes, and studying the overall impact. The paper calls for focused research effort from academics, industry practitioners, and policymakers to understand and operationalise the concept.

Practical implications: This study contributes to further the ongoing efforts to make global supply chains more transparent, sustainable, and resilient.

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Improving the Resilience and Sustainability Performance in Global Supply Chains- A literature review

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Purpose:
Logistics network and Supply Chain are exposed to different type of operational and disruption risks. Recent events, such as the Covid-19 pandemic, the war in Ukraine and the problem of fuel and raw materials supply, in addition to more frequent natural disasters and offer and demand shock, have shown the importance to revise the Supply Chains and Logistics in order to raise resilience by high-performance strategies ensuring capability to decrease the impacts of possible outages and to have a quicker recovery time. A crucial factor to reduce the vulnerability of the Supply Chain and Logistics is the preparedness and reactivity to unexpected events, based on (i) deeper awareness of the risks to which they are exposed, (ii) fast decision-making and (iii) new strategies and models that take into account economic, social and environmental sustainability.

In view of a highly variable and uncertain future, the growing digitalization of processes and progress in the use of big data through AI / ML are the keys for identifying new approaches and models for sustainable logistics. Raising the resilience of the supply chain requires a new approach to risk management, which must consider new global risk scenarios and complex mechanism of cascading effects, which determine unexpected impacts on logistics chain.

Improving Supply Chain Resilience as a part of SCRM has been in focus of research for the last two decades [1-5], but within other fields, like sociology and material science, research has been carried out for many more decades [3, p. 56]. During these last decades, tools and concepts like SCRAM (Supply Chain Resilience Assessment and Management) or LARGS (Lean, Agile, Resilient, and Green approaches in Supply Chain Management), as well as different frameworks for identifying vulnerabilities and capabilities have been developed, increased and adapted and we see an increase in published articles on the topic that look into different aspects that might increase the resilience.

The term resilience has evolved. In this RIA proposal we extend and adopt Fiksel's definition [6] as "the capacity for 'a supply chain and its environment' (original an enterprise) to survive, adapt (and grow) in the face of a turbulent change". In terms of adaptation of Fiksel's definition, we look not only to a single enterprise (at different levels), but to a whole supply chain and the interaction with the environment (ecosystem), since the last years have shown the relevance of having a holistic view. Nevertheless, have newly events like the SARS-2-COVID pandemic [4], natural disasters, the war in Ukraine, several shortages in material supply and shortage of qualified personnel/employees showed that the European economy is all but resilient, which indicates that research still needs to be carried in order to master the complexity and better understand the inter-dependencies. Even though all these events can be defined as disruptive events, but they have very different characteristics and also the source leading to the disruption varies. The impact is however in all cases that EU and its citizens and business entities are facing one shortage after the other, and the reasons for these are manifold [7,8]. Early works have already been done in integrating different sustainability aspects (above all, environmental, social and ethical aspects, organisational [9,10] and behavioural aspects [11,12]. However, due to the high complexity and the many interactions and dependencies of the different factors, the impact of a disruptive event varies, both for different supply chain stakeholders, as well as for different supply chain configurations, which makes the calculation and the understanding of possible outcomes of a disruptive event fuzzy and the decision-making process both more time consuming, as well as with a higher risk for making the wrong decisions. Based on the current SOTA research in resilience [3,13,14], this article presents the .

Research Methodology:
The structured literature review was carried out according to Pickering. It is designed to collect, classify and identify challenges in urban logistics related to stakeholders' interaction and engagement. In-line with Pickering (2013) a review protocol was established before we identified selection criteria, collected and analysed the data. It is followed by a results synthesis, and an evaluation of the SLR results.

Results:
We used a search string in Scopus, Web of science, Science direct, ACM digital library and IEEE Xplore. The papers were classified according to their main contributions to the topics in LARGS: LARGS – lean, agile, resilient, green, sustainable. Finally, we discuss the relation between the different components and how these may be connected to a set of key performance indicators.

Value/orginality:
This systematic literature review is of interest for practitioners interested in how different strategies impact on the company's competitiveness and resilience. It also provides a good overview of the state of the art in the relevant fields.

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Initial approach for AI-based real time global risk assessment in SCM

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Purpose of this paper:
Interest in AI text-processing systems is growing, while challenges in managing complex supply chains persist (Bavarian et al., 2022; (Bugert, 2022). The primary field of current AI-technologies is the "understanding" of information (Chui et al., 2018). For this reason, the ability to understand text underlying sentiment is substantial (Zucco et al., 2020). The paper explores AI's potential to assist with risk analysis in international supply chains by understanding underlying sentiment in information. The goal is to integrate these technologies into supply chain risk management and improve data mining in supply chain management. The process proposed serves as a starting point for further investigation of the practical usefulness of the generated data.

Methodology:
This paper uses the quantitative analysis of news articles from various temporally and geographically limited exemplary cases. The information collected from these sources is analyzed by a pre-configured AI model, resulting in the generation of variable expressions. Based on this output, a concept is developed that allows for the processing and integration of the generated information into operational risk management. From these cases, a conclusion is made regarding the general usefulness of this approach for business practice.

Findings:
This work shows that due to the high variance in the basic sentiment of news articles, even for topics that have no impact on supply chains (e.g., a lost soccer match), reporting can sometimes be very negative. However, a limitation of the search operators leads to the loss of the advantage of early detection. This work comes to the conclusion that by integrating another Machine Learning model which evaluates the probability of the relation to SCM, the results can be further improved. Also, in the existing form the presented approach represents a substantial advantage by the consolidation of the information.

Value:
The added value of the presented approach is derived from the long-term impact of the presented solution on operational SCM. A basis is thus created which makes it possible to identify outliers in the basic sentiment through a structured process and thus to achieve global coverage, which would otherwise be associated with a substantial effort. In addition, the continuity with which the analysis is performed creates a backup process that can expose red flags. Even if the model will return a comparatively high number of false positives, even one preemptively identified issue in a supply chain can mitigate the additional effort.

Research implications:
Process components of the presented approach can also be instrumentalized for other use cases. By combining the approach with other Machine Learning models, it can be examined to what extent the added value can be further increased and performance of the model increased.

Practical implications:
Due to the low costs of the approach and the high potential added value resulting from a identified risk, this is an interesting use case for companies. The reduction of complexity to one variable and the consolidation of a large amount of information into single key figures is a good starting point for institutionalizing weak signals in the analysis of Supply-Chain resilience.

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Imposing a deep production cut in the global supply chain disruption by using the digital supply chain twin

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Purpose of this paper:
In Global Supply Chain, a single disruption in any part of the network universally impacts the business after all; the company often shares a strategically established manufacturing facility with many regional business units. Thus, balancing supply and demand in manufacturing decisions is not straightforward anymore in this kind of multi-echelon supply chain. To manage disruptions in the multi-level supply chain, the digital supply chain twin (Ivanov and Dolgui, 2021) is suggested to shape the decision-making synchronized with the dynamics of the disruptions. This prospective study is designed to investigate the use of the digital supply chain twin, model-based and data-driven approach in reacting recovery planning.

Design/methodology/approach:
Recently experienced disruption in the supply chain, COVID-19 has motivated the elaboration of the manufacturing decision on how to react to the plummeted demands from all destinations of the goods. The decision involves customer order fulfilment service level as well as the total cost to serve the global supply chain. There should be a multi-objective decision support model that reflects all time-dependent parametric of the operations and disruptions. Given the manifested decline in demand, the manager of the factory needs to decide the duration of the production offline in a reactive way.

In this study, a Chinese construction machinery global supply chain with a Chinese manufacturing system is exemplified to demonstrate the effectiveness of model-driven decision-making under severe disruption in demands. To this end, the most promising offline period of the production line is extracted in a digital supply chain twin.

Findings:
The sharp cut event in demand leads to excessive stocks which soon causes unnecessary inventory holding costs such as interest expenses and facility costs without an opportune production cut as illustrated in figure (a). The digital supply chain twin could prove itself as evidence of the future supply chain tool(Ivanov and Dolgui, 2019) by providing the duration of offline production considering all stochastic variables in the multi-Eschelon supply chain network. This is one of the successful milestones that sustainability scientists aspire to after the lessons from the COVID-19 pandemic (Sarkis et al., 2020).

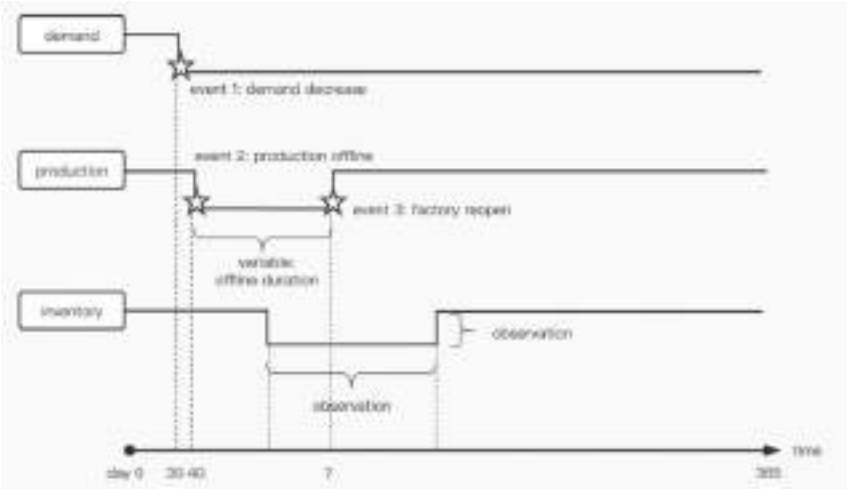

Figure (a)

Value:

This study fills the gap in the supply chain resilience literature in that a concrete and realistic application is proven in terms of its practicality and scalability. Whilst previous studies (Burgos and Ivanov, 2021; Ivanov, 2020) have been carried out on the passive examination of the impact of the disruption, there remains a paucity of research on reactive adaptation for the recovery of supply chain performance.

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An Investigation into the Impact of Brexit on Maritime Operations at Rosslare Europort

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Purpose of this paper:
This research aims to investigate the impact of the Brexit transition period on Irish ports, specifically, Rosslare Europort as a port of interest

Design/methodology/approach:
The methods employed to satisfy these research objectives comprise interviews, both structured and semi-structured, and questionnaires. The iterative Delphi method was adopted to evaluate the opinions of the small sample of stakeholders present at Rosslare Europort with the aim to gain unanimity on several topics. A heterogeneous collection of feedback was acquired on the performance of port actors, predicated on Port Performance Indicators (PPI) such as productivity, reliability and cost-efficiency alongside observations on Brexit preparedness, organisational priorities and stakeholder engagement.

Findings:
Both the impact of Brexit and the conditions necessary for its continuance are individualistic. The particularities witnessed at Rosslare Europort posed varying degrees of influence, specific to the port and the stakeholder classification, and observations at Rosslare highlighted the criticality of operational reform. Moreover, Although these port performance indicators claimed to be considerably sensitive to exogenous shocks in theory, the reality at Rosslare Europort was decidedly diverse. At Rosslare, productivity levels were not hampered as much as belief foretold and port stakeholders assumed a neutral position, neither agreeing or disagreeing with the former. Furthermore, the influence of Brexit on reliability and cost-efficiency factors was moderate to low, reiterating the individuality of personal experience.

Value:
Theoretically speaking, the observations made supplement pertinent research in both the contemporary challenges of the modern-day port and in robust supply chain design. The conclusions drawn may also be beneficial to industry professionals, with specific reference to Irish logistics and transport associates, as the commercially significant trading relationship between Ireland and the UK is at the centre of the study.

Research limitations/implications (if applicable):
The case study of Rosslare Europort itself acts as a limitation to the research concept, as are the many features that characterize the port. For instance, the observations made concern explicitly the handling of RoRo maritime freight and the distinctive geographical structure of the port and its stakeholder

Practical implications (if applicable):
The findings may prove useful for Irish port users that are considering the benefits of Rosslare Europort as an alternative choice.

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Logistics Service Providers in geo-political turbulence: Saints or Sinners?

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Purpose of this paper:

To investigate the behaviour of logistics service providers (LSPs) during the disruption caused by Covid-19 and the Russia/Ukraine conflict, to determine:

- Whether the LSP contribution has been the key to keeping supply chains flowing.
- Have all players using logistics services been affected in the same manner and to the same extent?

Design/methodology/approach:

Previous work (Gibson. RM., Savage. CJ., Gibson, V. 2021) has shown that, during a crisis, freight does get through supply chains, albeit with increased costs and interruptions, and that not all LSPs survive.

The study focused on LSPs in southern Africa, UK and Europe to examine regional differences and similarities in their performance, success and survival. It used a two-pronged approach; published financial and volume data enabled quantitative assessment whilst purposively selected semi-structured interviews and surveys identified themes, similarities, and differences in stakeholder perception of the industry's performance over the period.

Findings:

Preliminary findings show that there are differences in the way LSPs reacted to the crises. Some, European headquartered concerns, have enjoyed three years of growth and made significant profit improvements during the disruption and the intra-crisis periods (Ananjevas, 2022). Others, particularly capital-intensive organisations such as the state owned TransNamib railway company have struggled to continue to operate and some, e.g. Air Namibia have failed (Kato. R.L. 2021).

It suggests that LSPs with resilient approaches have been better able to flex their service offerings and generate greater revenue during this period. Those with an adaptable winning mindset in the pre, intra and post crisis phases have generated incremental revenue. Whereas those that failed to react quickly to revise their customer offering and/or are burdened by asset heavy or inflexible approaches, have been victims of the disruption with declining revenues.

Value:

The originality of this research is twofold; firstly, due to the recent / current nature of the causal events and secondly, to the use of comparative data from the established countries of Europe and those of the developing nations of southern Africa. Such a comparison has attracted only limited published research.

Research limitations/implications:

Limitations relate mainly to the reluctance of some organisations to provide accurate data. Implications concern greater understanding of how behaviour influences survival during disruption and which approaches to risk may be more appropriate for any future turbulence.

Practical Implications:

A toolbox to support organisations in adopting an up-to-date robust approach to supply chain risk and the management of service providers so they may be better equipped in dealing with future disruption.

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Creating Interorganizational Dynamic Capabilities in times of Supply Chain Turbulences

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Purpose:
In times of turbulences, firms would invoke their dynamic capabilities (DC) to manage disruptions and achieve resilience. The widely known DC theory framework — sensing, seizing, organizing, and transforming — is essentially firm-centric. It says little on how firms collaborate to develop interorganizational dynamic capabilities (IDCs) to jointly deal with disruptions to their supply chains.

Through a systematics literature review of papers grounded on DC theory and having a focus on interorganizational matters, Sandberg et al. (2021) delineated four types of IDCs based on their locus of control (i.e., whether the firm or network controls the IDC) and their beneficiary (i.e., whether the firm or network benefits most from the IDC): Exploitative (firm controls, firm benefits), Firm-based (firm controls, network benefits), Supportive (network controls, firm benefits), and Network-based (network controls, network benefits). While Sandberg et al.'s (2021) framework also identified the capability categories of the four IDC types, it has not dug into the processes under which IDCs evolve. Extending the well-known firm-centric DC framework, this paper draws on the relational view and the synergy lens to develop a conceptual IDC process model to answer the research question — how do IDCs develop through interorganizational collaboration?

Design/methodology/approach:
We extend the underpinning elements of dynamic capabilities — sensing, seizing, organizing, and transforming — from the perspective of a single firm to a network of firms by drawing on the tenets of relational view, focusing on their synergistic interactions to construct an IDC process model. We illustrate the veracity of our conceptual model by relating its structural elements — concurrent sensing, value convergence, relational synergy, and transilience innovation — to Boehme et al.'s (2021) findings of a longitudinal case study on how an additive manufacturing cluster in Australia was developed to supply personal protective equipment between 2019 and 2020.

Findings:
We theorize that in a turbulent environment, sensing, in the context of interorganizational or supply chain collaboration, has to co-evolve through a concurrent process among the collaborating partners (concurrent sensing). All partners perceive similar opportunities and constraints flowing from the disruption — how to leverage the opportunities created within the constraints delimited by the turbulence. Through information exchange and knowledge sharing, "concurrent sensing" gives rise to a shared vision among collaborating partners. We label this shared vision "value convergence", which drives the collaborating partners to explore the complementarity of their assets and resources to create "relational synergy", which equates to "seizing" in the well-known DC framework.

Through their collaborative interactions, collaborating firms reorganize their individual resources, bundling them into a collective structure to create a new set of capabilities. Because "the whole is greater than the sum of its parts," unprecedented network synergy begins to evolve from the interaction-induced changes as collaborating partners jointly navigate the turbulence to build transformative outcomes from the disruptive opportunities, bringing benefits to all collaborating partners. We call this "transilience innovation."

Value:

This study constructs a conceptual framework to explain how IDCs develop in turbulent environments to bring about transformative changes, offering a new paradigm in IDC research.

Limitations:

IDCs are context specific. Future research would benefit from exploring the boundary conditions of the proposed IDC framework.

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Logistics Network Design

The Macrologistics Effect of a Transport State-Owned Enterprise on an Emerging Economy: The case for South Africa

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Purpose of this paper:
Since South Africa is far from its trade markets and its major industrial hub is located inland, the efficient transportation of goods is critical. Most trade must also pass through its port system, meaning efficient port performance is critical for global competitiveness. Transnet, a transport state-owned enterprise, moves about 80% of South Africa's rail-friendly freight tonne-kilometres. However, if the rail-only coal and iron ore export lines are removed, Transnet moves less than 40%. This is indicative of deep-rooted legacy issues that have led to severe operational challenges that have recently been exacerbated by strikes, cyberattacks, and severe damage caused by floods and inclement weather. Port efficiency has also been deteriorating, with port charges among the most expensive in the world. This case study aims to explore these problems and calculate the resulting costs, negative externalities, and job losses to inform future reform possibilities. To that end, this research also aims to explore models that led to successful reforms in similar global cases.

Design/methodology/approach:
An overview of historical issues that contributed to Transnet's decline is provided by assessing rail freight's decreasing market share and infrastructure investment, port ownership and inefficiency concerns, deteriorating financial performance, loss of critical skills, and state capture. The economic cost of these failures are calculated by defining cost impacts across various freight flow segments, which are identified based on key flow patterns. The economic cost of rail and port failures are calculated separately and together, while the impact on employment is also quantified. International benchmarking and lessons extracted from relevant global reforms are used to suggest models to fix Transnet. Together these methods allow crucial recommendations on a way forward for South Africa to be made.

Findings:
The economic cost imposed by Transnet's poor operational performance is estimated to be 6% of GDP, meaning it is acting as a brake on economic growth, hampering job creation and development, and diminishing South Africans' quality of life. While there is no silver bullet to address the pertinent issues that must be resolved, a common phenomenon in the global solutions explored is a healthy relationship between government and the private sector. While South Africa has struggled on this front, recent government reforms acknowledge an elevated and meaningful role for the private sector. Similarly, the private sector are offering pragmatic and achievable solutions. This is a hopeful sign since South Africa depends on a successful collaboration, along with the development of port and rail master plans to guide the infrastructure development required to meet overall transportation needs.

Value:
Actionable implications related to policy implementation, shifting freight from road-to-rail, economic regulation and horizontal separation of the freight railway, funding mechanisms, protection of core rail components, corporatisation of the port authority, increasing port efficiency and capacity are provided. This research shows how business can contribute to Transnet's recovery by promoting and committing to greater private sector participation through privatisation of the coal and iron ore export lines and the involvement of experienced international operators to support rail and port reforms.

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An assessment of logistics outsourcing potentialities in Nigeria

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Purpose of this paper:
This paper aims to assess the potentialities of outsourcing logistics activities in Nigeria. There is currently a dearth of cross-sectoral analysis of logistics outsourcing practices in Nigeria with previous research tending to draw conclusions from only one sector.

Design/methodology/approach:
A structured questionnaire was carried out using a mixed-methods design. Fifty-one companies comprising large corporations and small to medium scale enterprises representing various sectors in Nigeria were contacted for primary data collection. Of the fifty-one companies contacted six major organisations responded to the questionnaire, representing several large sectors in Nigeria including manufacturing, FMCG, Agriculture, pharmacy/healthcare and a major third-party logistics player. The respondents also represent a substantial proportion of total logistics outsourcing activity in Nigeria. A descriptive statistical analysis was conducted on the primary data providing insights and the primary data results were cross-checked against the literature focussing on the third-party logistics market in Nigeria and similar developing countries.

Findings:
Preliminary findings indicate that 60% of companies in Nigeria and similar developing countries outsource only basic logistical functions such as transport and distribution and some warehousing functions (for storage), leaving lots of opportunities for growth in, for example, inventory management, order management, customer services, packaging and materials handling, warehouse design and management and value-added services.

Value:
Current and potential third-party logistics players and their clients in Nigeria may gain insights from this paper to make better business decisions, more specifically to provide and make further use of outsourced logistics services, where feasible. The cross-sectoral nature of the data allows for sector specific insights into why logistics outsourcing practices may be higher or lower relative to other sectors.

Research limitations/implications:
Primary data collection in Nigeria is notoriously challenging leading to the typically low response rate seen for this paper. This prevented the authors from undertaking inferential statistics on the data despite the many descriptive insights that can be drawn from the analysis.

Practical implications:
This research allows organisations from different sectors in Nigeria to see what the barriers and opportunities are for further growth in logistics outsourcing activity through the expert insights gained in the questionnaire from a wide range of sectors in the country.

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Industrial Parks, Logistics Connectivity and Resilience for Developing Regions: A Resource Orchestration Approach

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Purpose of the paper:
Developing regions globally face numerous challenges on trade and logistics. Such regions though well-endowed in natural resources possess limited options for external connectivity, unpredictable product demand, nascent production scale, and costly yet unreliable transportation means. Therefore, the purpose of this paper is to communicate the challenges of logistics connectivity for developing regions using a case study involving industrial parks in a region in Southeast Asia, and to provide a nuanced framework for managing this challenge.

Design / methodology / approach:
We employ open data to our unit of analysis which in this case is the largest and most resource rich state in Malaysia. Specifically, we assess five industrial parks planned for this state, and their attendant logistics connectivity challenges. Additionally, we consider the costs of connectivity and the environmental footprint.

Findings:
This study presents a framework to assess the level of interventions needed to connect the industrial parks to the rest of the world. We show that the resources orchestration theory can be applied to configure the industrial parks and logistics connectivity.

Value/ originality:
Industrial park development has been studied before, and many non-governmental agencies such as the World Bank have examined the need for robust logistics connectivity. This study contributes to a deeper understanding of the proverbial chicken and egg discussion by suggesting that industrialization and building logistics connectivity must go in tandem.

Research limitations/implications:
This paper has several limitations. First, the actual data of operating in a specific environment and for a specific industry are not forthcoming as much of the work is work-in-progress. The second limitation is that only open domain data are available to the authors, even though there is evidence to suggest that other richer forms of data exist and have been collated. This paper studies the need for a theoretical lens to appreciate the co-development of industrial parks and logistics connectivity. One possibility is to call on the more recent resource orchestration theory to explain the causes and effects of capabilities generation.

Practical implications:
By providing policy and management with a framework on the various interventions that can take place to expedite the concurrent development of industrial parks and logistics connectivity of a developing region, decision makers and enterprise can then make more informed decisions regarding the avenues to invest in either industrial park improvement, logistics connectivity improvement (and their various modalities), or both.

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Mapping macrologistics value chains in Southern Africa

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Purpose of this paper:

Most African countries have small domestic markets, limited economic diversification, and long distances to markets. The latter is exacerbated by poor connectivity with neighbouring countries, which further elongates supply chains. The economic spill over effect macro events in major – and key trading partners economies has on developing economies was evident by the impact of lockdown measures in Southern Africa. These spill over effects were compounded since the region is dependent on primary product exports, which highlights the importance of empowering and diversifying local economies to reduce exposure to negative economic shocks. This research aims to describe the overarching nature of freight-flows in Southern Africa to better understand pertinent value chains issues. Thereby, this research aims to provide key focus areas for macrologistics based on the mapped value chains.

Design/methodology/approach:

Five overarching freight-flow segments in South Africa and the modelled Southern Africa, namely agricultural, large volume export mining, domestic mining, semi-beneficiated goods and finished goods flows, are mapped according to the nature of the commodity and service requirement. This allows the domestic, import and export freight-flow volumes related to the basic economic value chain to be provided. Key macrologistics descriptors are then highlighted, followed by a description of key macrologistics focus areas based on the mapped value chains and their most significant issues.

Findings:

The rest of Southern Africa is extremely reliant on grain imports – much more so than in South Africa. What makes this especially concerning is the region's lack of sufficient transport infrastructure to facilitate this vital import trade. Since people in Southern Africa are hamstrung by severe hunger, it's imperative to improve bulk transport efficiency – especially that of cross-border movements since many countries within the region are landlocked. Port capacity is also challenged by massive handling volumes, especially in South Africa where bulk mining exports are the heartbeat of its economy. With manufacturing commodities' contribution to GDP dwindling in the entire Southern Africa, high volume-low value flows to ports are substantial. The survival of the South African economy is largely dependent on getting these commodities to ports, which was illustrated by recent disruptions (i.e. floods and strikes) bringing its global trade to a near standstill. This port vulnerability might put the country and overall region at risk if a food (or other humanitarian) crisis arises.

Value:

This research provides evidence of significant value chain issues, namely long distances causing high transport costs, corridor funding challenges, low beneficiation levels and upstream distortions, and over-reliance on trucking. Thereby, this research underscores macrologistics areas that require immediate attention for the betterment of the mapped value chains in Southern Africa. For South Africa, improved use of rail transport and the establishment of more efficient connectivity to ports and rural road networks can alleviate most of its value chain issues. In the rest of Southern Africa, stunted economic growth needs to be stimulated by focusing on capacity development for mining commodity transport to fund other investments for example local beneficiation and community upliftment.

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Transport & Distribution

Spatial analysis to e-commerce warehouses in South Korea

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Purpose of this paper:
With the growth of the e-commerce market, strategic logistics facilities are becoming a new competitiveness for domestic e-commerce companies to provide last-mile delivery services with shorter response time. This paper aims at investigating how e-commerce warehouses are spatially distributed and what factors determine location of e-commerce warehouses in comparison to general warehouses.

Design/methodology/approach:
The spatial analysis is conducted using Moran's I and Getis-Ord Gi index to investigate how spatial clusters of logistics warehouses are formed over time and type. In addition multiple regression analysis is used to what factors influence location of warehouses. The data is collected from metropolitan area of South Korea.

Findings:
E-commerce warehouses tend to be distributed relatively sporadically while general warehouses are concentrated in the southern part of Gyeonggi-do. It was also found that e-commerce warehouses tend to be more located in areas with higher rent and higher labor availability but with lower population density while general warehouses tend to be more located in areas distant to highway interchanges to avoid higher rent.

Value:
The existing literature lacks empirical analysis on spatial distribution of e-commerce warehouses due to limited data availability. This study differs from previous studies in that it visualizes the spatial distribution of logistics warehouses using empirical data and investigates factors of spatial distribution of e-commerce warehouses.

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An investigation into factors influencing truck payload

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Purpose of this paper:
Efficiency is critical in logistics where performance depends on several factors such as facility design, nature of operations, available resources, equipment, technology, and management. Maintaining target truck payloads for recycled fibre can be challenging, we have engaged with a company that provides recycling services to investigate the main factors influencing the payload across the network collected by their fleet or through 3PL. The main motivation for the project is to address a key challenge related to driver shortage in addition to supporting their sustainability agenda, to reduce carbon emissions per tonne of product. Covid and Brexit had a significant impact on the lorry driver shortage and the Road Haulage Association estimated a shortage in excess of 60,000 drivers (RHA, 2021).

Design/methodology/approach:
A mixed method approach has been used in this study and includes interviews with four managers, process mapping and identification of opportunity areas, a site visit, simulation, and viability analysis to justify the improvement implementation concerning improving payload variability and related savings.

Findings:
The research identifies factors influencing a trailer payload that are associated with process factors, data availability and fragmentation, process standardisation and other operational factors. It identifies specific retailers' locations among recycling service units, distribution centres or export facilities where trailer loads require further improvements. We also investigate technological solutions and propose a provisional solution to support payload improvements.

Value:
This study extends the knowledge related to freight efficiency movements on the road and focuses on the utilisation of carrying capacity. It also evaluates the quality of available data and considers how it might be improved to support further development of a sustainable solution.

Research limitations/implications:
The research focuses on recycled services and recycled fibre. Future research may also consider other applications to allow further generalisation of the model.

Practical implications:
The results from this study inform the logistics industry on the development of a sustainable solution to manage factors influencing truck payload.

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Testing the spatial dynamics between logistics restructuring and truck crashes over time in South Korea

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Purpose:
Over the last decade, production and distribution networks have been globalized, and retail/logistics companies fiercely compete to fulfill ever-increasing consumers' demand for instant delivery. Such changes have reorganized the geography of goods supply chains at the national scale (Bowen, 2008). We may expect changes in freight flows, which would lead to changes in truck movement patterns (e.g., travel distance, and frequency) and negative externalities (e.g., congestion and vehicle crashes). Logistics companies strive to optimize truck movement patterns and associated costs. However, unexpected events, such as truck crashes, disturb the optimized logistics strategies and incur significant costs. Hence, proper road safety planning is imperative.

This research examines the factors that explain the spatial dynamics of truck crashes over time in South Korea. Among various risk factors, we focus on testing the association between the built environment – e.g., logistics system accessibility – and truck crashes, controlling for various exposure variables. As crash risk factors, the built environment has been rigorously and empirically tested (Merlin et al., 2020). However, few studies have analyzed the relationship between freight land use and truck crashes. With this paper, we aim to fill the research gap.

Methods:
To explain the spatial distribution of truck crashes, we use a vector of logistics system accessibility as the primary explanatory variable (*transport supply, S*), which includes access to logistics parks, access to industrial parks, the shortest distance to transportation nodes, and warehouses. Population density is used as a control variable for urban structure (*transport demand, D*). As a measure for exposure, a composite variable consisting of the number of population, registered vehicles, and road length is used (*exposure, E*). We adopt a spatially disaggregate analysis, using a spatial unit of a city and county-equivalent (Noland & Quddus, 2004). A conceptual model is presented as $Y=f(S, D, E)$. To account for the spatial autocorrelation, spatial lag X, Y, and Durbin models are used. Approximately 500,000 truck crash records (2003-2005 and 2017-2019) were provided by the Korea Trucking Association (KTA), which governs an insurance and mutual aid fund for commercial freight vehicle accident compensation. In total, 5,800 truck crash records were examined.

Findings:
Spatial analysis results indicate significant heterogeneity in the distribution of truck crashes over time, road type, and spatial units. Over time, yet with a decreasing number of truck crashes due to various road safety measures, more crashes are concentrated on highways (27% in 2003 vs. 34% in 2019) and certain jurisdictions. Econometric analysis results indicate changes in the factors that explain truck crashes over time, weakening ties with traditional freight focal points, the consistent significance of contemporary warehousing activity with various logistics functions, and omnipresent trucking activity, regardless of urban structure, that is, urban logistics.

Value and Research Implications:
The heterogeneity in the geography of truck crashes over time suggests the need for a clear understanding of truck crash risk factors aside from logistics system accessibility. Indeed, logistics systems have faced abrupt restructuring in how goods are distributed, and trucks are now making more deliveries in residential areas. New perspectives on freight transportation planning and road safety management have become necessary.

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Effects of meteorological conditions on fuel consumption of business fleets by using gps trajectory on digital road map

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Purpose of this paper:
Efficient business fleet operation is an important goal because fleets play crucially important roles in modern society. For the purpose, (Takeno et al. 2022) have presented statistical analyses on relations among fuel consumption and road conditions such as altitude, velocity, and road category. This paper is a companion of (Takeno et al. 2022). We introduce two explanatory variables: temperature and precipitation. We present effect of meteorological conditions on fuel consumption in comparison to road conditions.

Design/methodology/approach:
We have obtained GPS trajectory records of actual business fleets from collaborative research partner. The records are stored in Data Centre of truck manufacturer. Each of the record is selected from that vehicle run identical motorway. However, every trip varies in month, precipitation and direction.

The records are applied Map-Matching System to identify accurate position on Digital Road Map. Here, Digital Road Map is a graph comprised with vertex and edge which represents Road network in digital. Altitude and Inclination are calculated with attribute information in Digital Road Map. Japan Meteorological Agency provides past meteorological data by every 10 minutes at their website. We have obtained temperature and precipitation data on the day of vehicle's trip.

We have conducted Multiple Regression Analyses in which outcome variable is fuel consumption. Because we could not obtain data for another variable that represents current vehicle condition. We have adopted five explanatory variables: altitude, inclination, velocity, temperature and precipitation. Here, altitude, inclination and velocity are the same with (Takeno et al. 2022). Therefore, outcome presents comparison between conventional variables and meteorological variables. Here, to reduce effects of magnitude of value, all explanatory variables has been normalized.

Findings:
Analyses are done for two models of which definition of point is different. From the outcome of Multiple Regression Analyses, altitude, inclination and velocity are significance in $p<0.05$ for both models. Inclination showed the largest effect on fuel consumption as absolute value of coefficient is more than 15. Velocity is second in which coefficient is more than 4. Temperature became significant in one of the models. In that case, coefficient was 0.19. Through the analyses, order of strong effects on fuel consumption is Inclination, Velocity, Altitude, Temperature and Precipitation.

Value:
We present a methodology to statistical analyses for impact of meteorological effect on fuel consumption as a condition of business vehicle. Life of parts and components can be candidates of the outcome variables with the methodology.

Research limitations/implications (if applicable):
Analyses is conducted only for the same vehicle model, the same motorway to reduce effects of difference except for explanatory variables. Used GPS records were proved in 2021. Range of Temperature and precipitation were depending on the year.

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Clustering the ports in South Korea based on the PM concentration using Dynamic Time Warping

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Purpose:
Air pollution derived from various transportation modes made people aware of the need for policies to prevent air pollutant emissions. As part of the policy, air pollution monitoring stations have been established worldwide, and in some countries like South Korea, air pollution measurements at specific logistics facilities such as ports have become possible. As the data from air pollution monitoring stations are accumulated, the idea of this study began with the following questions: Is the time-series-based PM(Particulate Matter) concentration of a port formed by the characteristics of the port, such as the number of anchored vessels or the amount of loaded or unloaded cargo? Or is it formed by geographical features? Therefore, this research is designed to cluster the ports in South Korea based on the PM (Particulate matter) concentration and to analyse the characteristics of each cluster.

Design/Methodology/Approach:
Various distance measures can be used to figure out the similarities between multiple time series data. When analysing the similarity of time series data, Euclidian distances, which measure distances on the same time line, are often used. However, this generally means that similarities cannot be found as the movement becomes more severe in data that looks similar in patterns. Dynamic Time Warping(DTW) is a distance measurement method designed to solve this problem. DTW calculates the distance to more similar elements by using data on the same timeline as well as comparison to the peripheral point in time. Therefore, we conduct various clustering algorithms, such as K- means clustering, hierarchical clustering, fuzzy C-medoids clustering, based on DTW. Various cluster analysis algorithms will be used to confirm the consistency of the cluster analysis results.

Findings:
Based on the result of Elbow method, which is used to determine the optimal number of clusters, it reveals that PM data for fifteen ports are grouped by five clusters. Cluster 1 consisted of Janghang, Kunsan, and Mokpo port. Donghae, Gyeongin, and Mukho port are assigned in to Cluster 2. Cluster 3 is comprised with Daesan, Incheon, and Pyeontaek port. Busan, Gwangyang, Masan, Ulsan and Yeosu port are grouped into Cluster 4. In addition, Pohang port is a single member for Cluster 5.

Values:
This study contributes to the relatively small body of literature on port clustering based on the PM data. Moreover, in a situation where the same fine dust reduction policy is implemented for each port, it will help to establish a differentiated policy according to the fine dust characteristics of the port.

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Human Resources Management (HRM) Practices and Seaport Competitiveness: A case of Nigeria

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Purpose of this paper:
Nigerian seaports remain uncompetitive despite many reforms, including a modernisation project by the World Bank. Some of the critical challenges that Nigerian seaports currently facing include – inadequate logistics and infrastructure, poor regulatory and policy implementation, and unethical practices and poor management. These have resulted in inefficiencies that have impacted competitiveness of the seaports. The purpose of this study is to examine the role of human resource management (HRM) practices in enhancing seaport competitiveness through the adoption of technology and building workforce capability.

Design/Methodology/approach:
Through the extensive review of literature, a conceptual framework is developed with HRM practices, technological capability, workforce capability, and corporate governance constructs as the drivers of seaport competitiveness. Case study approach was adopted for the study. A multiple case study was used to conduct an analysis of the six Nigerian seaports. Qualitative data was collected using semi-structured interview protocol. Nineteen seaport executives who are working in these seaports were purposely selected and interviewed. To analyse the data, a qualitative content analysis was done using NVivo program analysis.

Findings:
The paper established that modern technologies and infrastructural availability without proper engagement of human resource to stir the workforce in the right direction, will not work and therefore will not have any positive impact of competitiveness. The results demonstrated that there exist a direct association between HRM practices and workforce and workforce capabilities and in turn both technological capability and workforce capability influence port competitiveness. In addition, it was also found that the relationship between HRM practices, workforce capability and technological capability is moderated by corporate governance.

Value:
The paper contributes to literature in demonstrating that HRM practices is related to seaport competitiveness via building technological and workforce capabilities. The findings can be used for effective policy development for the government and seaport authorities and a benchmark for other African seaports to become competitive.

Research limitations:
This qualitative case studies are limited to six seaports in Nigeria. Thus the conclusions drawn from this study are limited to Nigeria seaports only, although it can be used for benchmarking of other seaports in Africa. By focusing on seaport executives only, the study may not allow full understanding of the poor performance and ineffectiveness of the Nigerian seaports.

Practical implications:
This paper will provide step-by-step guidelines for the seaport managers and executives to develop and implement policies that will enhance seaport competitiveness.

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Utilising freight demand modelling as an integrated evidence base to improve container logistics supply chains: The case of the Port of Cape Town

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Purpose of this paper:
This case study aims to utilise freight demand modelling to serve as an integrated evidence base for short- to medium-term capacity planning and intervention implementation related to the Port of Cape Town (PoCT). These interventions are aimed at improving the efficiency of the port's container logistics supply chain and facilitating appropriate service level capacity to accommodate anticipated export growth in the Western Cape. By enhancing the Western Cape Freight Demand Model (WC FDM™), this research aims to enable increased disaggregation of the port's cargo flows, namely by containerised and non-containerised cargo, container type, month, fruit commodity – and larger commodity groups.

Design/methodology/approach:
Since this research enhances the pre-existing WC FDM™, an overview of the model's is presented to provide its background and methodology. The additional fruit data required to enhance the model is described to illustrate how it is integrated with the WC FDM™. Following integration, an overview of the enhanced model is included, detailing the newly achieved levels of data disaggregation. Using the enhanced cargo flows, this research then models how weather delays and cargo perishability affect them to make recommendations for efficiency improvements at the PoCT.

Findings:
Important interventions at Cape Town Container Terminal (CTCT) include protecting the terminal against the impact of weather delays, improving terminal intelligence, and re-thinking current container approaches. In the context of Western Cape Government (WCG), developing a centre for transport planning related to the PoCT will help it become a stronger, more capable, and responsible regulator. This will contribute toward ensuring the WCG's policy positioning and regulatory frameworks aid in reforming the port and terminal to optimise their service delivery.

Value:

This research provides evidence of the level of containerisation at the PoCT, including meaningful insight into dry and refrigerated 20-foot and 40-foot containers' contribution to overall, and more specifically containerised, import and export trade. The enhanced model's fruit commodity disaggregation by month provides a valuable overview of fruit seasonality. By showing current and projected seasonality, along with modelled outputs of the related impact of weather delays and levels of fruit perishability, this research identifies key areas of port efficiency and capacity improvements.

Research limitations/implications (if applicable):
The calculation of loss related to CTCT delays is an important functional capability which can be explored in future research to improve efficiency at the port and the terminal. The production region location information in the input data can be improved to allow flow maps for additional fruit commodities to be produced, which will increase the current evidence base considerably.

Practical implications (if applicable):
The CTCT can mitigate the impact of weather delays by increasing the capacity of its quay wall crane offering and adding capacity for dry cargo. Terminal intelligence can be improved by increasing the level of data coordination between its stakeholders and using increased data outputs used in loss calculations due to terminal delays to enable appropriate trade-offs, which in turn, can inform better decision-

making. The terminal can realise greater efficiency by manufacturing refrigerated containers locally or using them for dry imports.

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A bibliometric study based on seafarers psychological issues: hotspots research and future agenda

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Abstract:
Recently a significant research has carried out in the seafarer's zone. Different research studied different areas. However, this literature review has carried on the bases of seafarer's psychological issues, to know the current state of research in the seafarer's domain, most dominant region, authors, journals, institutions and keywords in term of research publication related to seafarer's and also provide hotspots of the research. In this paper, Cite Space and VOS viewer were used as bibliometric analysis tools to get a thorough understanding of Seafarers health and accelerate the current research. The main source for data collection was the Web of Science core collection database. The dataset was consisting of 470 papers from 2010 to 2022. Seafarers related theoretical knowledge and popular research topics mainly revolved around "seafarers" "stress" "accident" "Health" "transposable elements" "life" and "fatigue". To identify new research trends and frontiers, a cluster analysis using a keywords perspective was conducted. The findings indicated that health related issues such as mental health, onboard performance, should be the focus of future research. However, this literature review has carried on the bases of seafarer's mental health. Therefore, this paper helped academics and industry professionals gain a thorough understanding of the current state and future directions of seafarer's research.

Customer-Supplier Relations

Supply Chain Risks and their importance for SMEs in Construction Projects: A Structured Literature Review and Research Agenda

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Purpose of this paper:
Whilst there has been much research examining risk management in construction supply chains, there is a relative dearth of knowledge concerning Small and Medium sized Enterprises (SMEs) in this context. *This study identifies risks from an SME perspective, from which a determination of relative risk significance is shown.* A ranking for the importance of each risk factor is derived, and this subsequently supports decision-making recommendations.

Design/methodology/approach:
A structured literature review was conducted to identify risks for SMEs from typical articles. Which 94 relevant studies were identified. Thematic analysis was then utilised to determine the supply chain risk themes. In assessing the importance of supply chain risk, the Analytical Network Process (ANP) was employed, using data gained from risk ranking obtained from interviews with construction experts.

Findings:
Firstly, the status of research on the supply chain risk of construction for SMEs is described. Secondly, a comprehensive set of supply chain risks in the construction industry are identified. Thirdly, the ranking of importance of supply chain risks is identified, which is relevant to industry, academia, and policymakers alike.

Value:
The novelty of this paper is a comprehensive study of supply chain risk management of SMEs. Due to the limitation faced by many SMEs in terms of resources and management capabilities, it is unlikely for them to gain comprehensive experience in dealing with risks at an early stage, where the first several severities of risks are likely to be solved first. From the government's point of view, it is crucial to support the creation and development of SMEs, especially in the construction sector, which is very important in terms of GDP. Therefore, the key is to develop systematic risk management. This paper establishes a risk management scheme for SMEs by conducting comprehensive research on the supply chain risks.

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Manufacturing Logistics

The impact of supply chain technologies on the visibility and responsiveness of manufacturing supply chains in developing economies

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Purpose of this paper:
The main purpose of this study was to examine the extent to which supply chain technologies impact visibility and responsiveness in manufacturing supply chains with reference to developing economies.

Design/methodology/approach:
The study was a cross-sectional quantitative research design. Questionnaires were employed for the data collection with the data collected from 205 manufacturing firms operating in Ghana. The questionnaires were self-administered purposively to the participants who were mainly supply chain managers, procurement managers, operations managers and other related functions. The Partial Least Square-Structural Equation Modelling (PLS-SEM v.40) was adopted to explore the structural relationships between supply chain technologies and, visibility and responsiveness in supply chains of manufacturing firms.

Findings:
Supply chain technologies were proxied using big data, Internet of Things (IoT), Addictive manufacturing, Collaborative robots, Augmented reality and Artificial Intelligence. The study had twelve hypotheses out of which six were supported by the findings of the study. The direct relationship between big data and supply chain visibility, big data and supply chain responsiveness, IoT and supply chain visibility, Augmented reality and supply chain visibility, Augmented reality and supply chain responsiveness, collaborative robots and supply chain visibility, collaborative robots and supply chain responsiveness were found to be statistically significant. Thus, in developing economies, supply chain technologies may have differential effects on supply chain visibility and responsiveness with respect to manufacturing operations.

Value:
The study contributes to the extant literature on emerging supply chain technologies and their relevance in enhancing supply chain performance in the context of developing economies. The study has explored six key emerging supply chain technologies to understand their influential effect on enhancing visibility and responsiveness in manufacturing supply chains. These research outcomes enhances understanding on the importance and capabilities of these technologies within manufacturing operations in developing economies.

Research limitations/implications (if applicable):
The study investigated only six supply chain technologies and two measures of supply chain performance. Future studies may explore further, the relationship between the same or other supply chain technologies and other supply chain performance dimensions such as integration, efficiency, and quality. Furthermore, the study was limited to manufacturing firms operating in Ghana hence the generalizability of the findings should be done with cautions due to contextual conditions.

Practical implications (if applicable):
The paper has significant practical implications to practitioners and captains of the manufacturing industry. The findings on the relationship between supply chain technologies and supply chain visibility and responsiveness may inform manufacturing firms' decision on which technologies are necessary for improving their supply chain performance. The result of the study may further inform operations and supply chain managers to selectively invest in supply chain technologies on the basis of the objectives they want to achieve.

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FULL PAPERS

Sustainability in Logistics and Supply Chain Management

Collaboration in the pharmaceutical supply chain to improve inventory management: A framework for practitioners

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INTRODUCTION

In a pharmaceutical supply chain, the manufacturers are the pharmaceutical firms, the distributors are the drugs wholesalers, the retailers are the hospitals/clinics/pharmacies, and the customers are the patients (Kim, 2005). The covid19 pandemic has made the importance of collaboration across the supply chain in the pharmaceutical industry clear to the public. However, knowledge sharing across the supply chain requires implementation of supply chain tools which can allow for information sharing on anything from product design ideas to inventory management.

The pharmaceutical industry has traditionally focused on R&D investments and has high margins for their products (Mayer, 2012). This has meant less attention to cost efficiency and limited lean implementation in this industry compared to other manufacturing industries overall (Shanley, 2016). Hence, it is estimated that the health care industry could save approximately $23 billion per year in supply chain costs in the United States alone (Kim, 2005).

However, the cost of developing medicines is increasing, lowering return on investment (Ward, 2015) and making cost efficiency a key competitive advantage (Aptel, 2001). Inventory management plays a key role in creating a more cost-effective supply chain and is a first basic step towards increased collaboration across the supply chain (Almarsdóttir & Traulsen, 2005). In the pharmaceutical industry there has been limited collaboration, resulting in a tendency to overstock (Shanley, 2016), creating large holding costs and recurrent discard of perishable products (Rachmania & Basri, 2013). Therefore, this research will focus on knowledge sharing relating to inventory management as a key first step towards greater collaboration across the supply chain.

Various inventory optimisation methods for this industry have been debated, e.g. mathematical models (Chaoleam et al., 2013), specific technologies (Gallus et al., 2014) and lean methodology (Jonet, 2013). However, the research in this area is fragmented. There is subsequently a research gap regarding a holistic overview of the potential tools to optimise a pharmaceutical supply chain which is operational for organisations. This paper addresses this research gap by creating a framework for practitioners in pharmaceutical organisations focused on inventory collaboration.

LITERATURE REVIEW

Below is a summary of the factors influencing inventory management in the pharmaceutical industry (Uthayakumar et al., 2013; Kim, 2005; Rachmania & Basri, 2013; Mouaky et al., 2016; Candan et al., 2016; Vila-Parrish et al., 2008; Kelle et al., 2012). A factor is defined as a characteristic of the supply chain or the firm having a direct impact on inventory management, i.e., how the firm is organizing its inventory policies. Managerial factors like resistance to change is not included in this research as these are general factors, not specific to this research aim.

Factor 1, Visibility: How information is recorded and communicated along the supply chain. Is impacted by: Difficulty level with inventory tracking, coordination issues, level of efficient information sharing, level of IT support, level of effective communication, level of available demand and inventory information, level of accurate inventory records, amount of unconnected links between customer and purchasing department, amount of errors in inventory records and storage and the level of implementation of inventory control systems.

Factor 2, Uncertainties: Situations in the supply chain where uncertain demands trigger overstock and prevent efficient scheduling. Is impacted by: Level of uncertainty due to many different products,

level of changing demand, level of uncertainty in the demands for existing drugs, level of safety stock due to demand uncertainty, level of unpredictability in demand and level of difficulty in keeping inventory records.

Factor 3, Lead time: Latency between the placement of the order and the delivering of the product to the point of care. Is impacted by: The perceived necessity to buffer for long lead time, how long lead time is set in control systems and how long set-up time is.

Factor 4, Diversity of products: Complexity of product portfolio and the degree of personalization of drugs. Is impacted by: The number of different drugs and the degree of personalization in dosing and combinations.

These factors can be correlated, meaning the positive or negative variation of one factor leads to changes in another. E.g., the diversity of products has a direct influence on uncertainties. Demand variability will increase if an ample variety of products is produced. The variety can also have an adverse impact on lead time, as producing more different products involves more different set-up procedures. Also, better visibility can also have a positive effect on lead time, by improved job scheduling (Weiner, 2014).

Literature has introduced tools and frameworks which foster knowledge sharing across the supply chain. These can also be divided into the four factors, with potential pros and cons as shown in table 1 (King & Zhang, 2007; McKinsey & Company, 2016; Chaichoopara, 2015; Cheng, 2016; Baldi & Vannoni, 2015; Pekgun, 2016; Jonet, 2013; Eberlea, 2014; Baldi & Vannoni, 2015; Sauvaget, 2016; Kritchanchai & Suwandechochai, 2010; Mubashir, 2013).

Factor	**Tool**	**Pro and Cons**
Visibility	VMI	(+) Reduction in customer demand uncertainty (-) Loss of privacy on data sharing (+) Reduction of inventory level (+) Reduction of stock out number and frequency
	RFID	(+) Auto-ID inventory (+) Reduction of mistake from the nurse side (+) Better trackability of drugs/doses (-) Privacy protection
	Cloud Analytics	(+) Reduction of lead time (+) Better forecasting accuracy (+) Better productivity (-) Skilled employees are required
Uncertainties	Forecast	(+) Reduction of cost with differentiate forecasting (+) Better long-term capacity planning (+) Better management of intermittent demand
	Centralization	(+) Less stock level thanks to risk pooling (+) Internalization of the production (+) Higher coordination (-) Lead time increasing
Lead time	Lean methods	(+) Reduce the lead time, e.g. renouncing batch production (+) Implementation of Kaizen methods (+) Reduce setup time, e.g. Single Minute Exchange of Die
	MC simulations	(+) Improvements scenarios for sensitive sub processes (+) Good prediction of lead time variability (-) Staffing hours harder to schedule (-) Might reduce economies of scales saving
Diversity of	Dose banding	(+) Lower unit cost of products (+) Less pressure for hospital staff (+) Negotiate lower prices with supplier

products/ doses		(+) Aggregation of orders
	Products portfolio reduction	(+) Aggregation of orders
	ABC/VED Classification	(+) Better economic impact analysis of products (+) Adapted inventory management techniques for different groups of products (+) Better service level considerations (+) Stock out reduction

Table 1: Overview of pros and potential cons for the tools

Each tool can be divided into major and/or minor tools, depending on whether their implementation will have a direct or indirect influence on the four factors:
Factor 1, Visibility: Major tools: VMI, Cloud analytics, RFID. Minor tools: N/A.
Factor 2, Uncertainties: Major tools: Improved Forecasting Methods, Inventory Centralization VMI, Cloud analytics, RFID. Minor tools: Cloud analytics.
Factor 3, Lead time: Major tools: Lean methods, MC simulations, Dose banding. Minor tools: Inventory Centralization, Cloud analytics
Factor 4, Diversity of products: Major tools: ABC/VED analysis, Portfolio reduction, VMI, Cloud analytics, RFID. Minor tools: N/A.

THE INVENTORY MANAGEMENT INFLUENCE NETWORK (IMIN)
These findings were combined to create the Inventory Management Influence Network (IMIN), a graphical representation is shown in Figure 1. Ring 1 includes the four factors introduced above. Ring 2 includes the direct tools and ring 3 the requirement tools (tools needed to implement other related tools). Ring 4 show the synergetic tools (tools having a positive influence on other tools performance). A red line shows a negative relation, a blue line a relation, a dotted line a proposed relation and +/− indicates relation type.

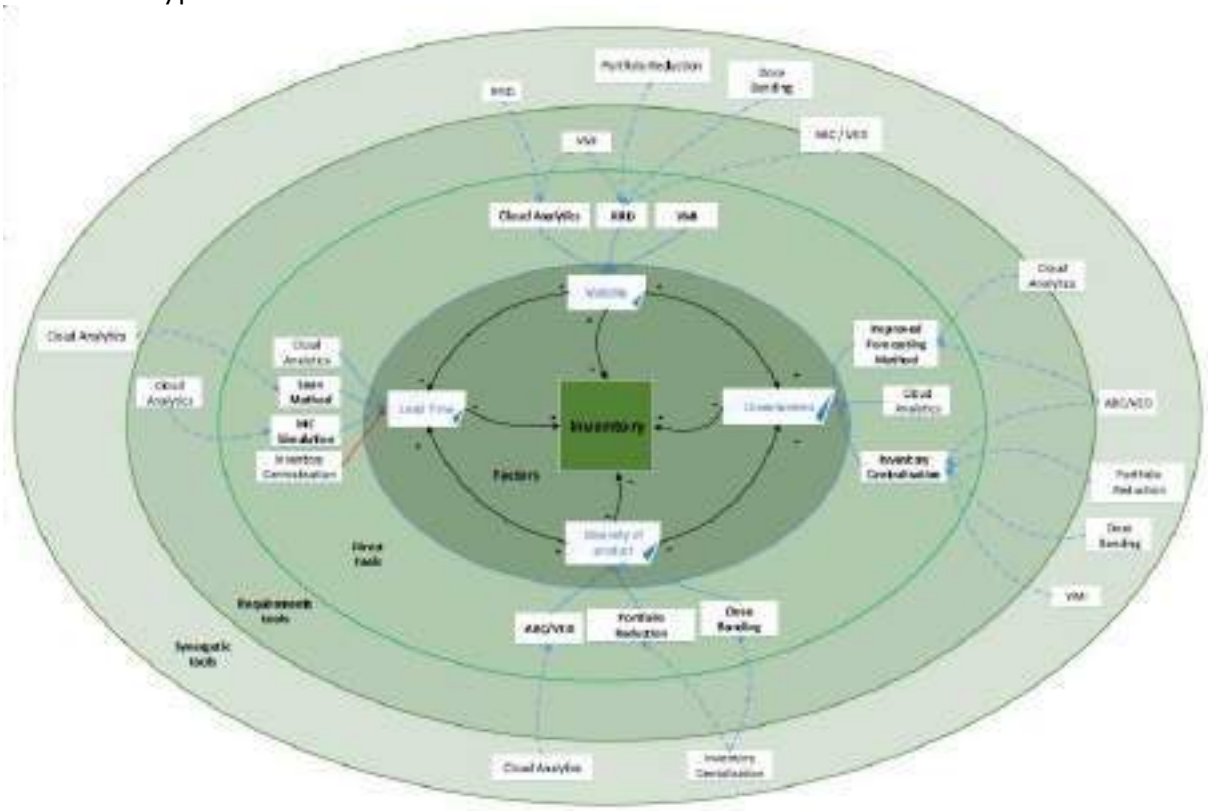

Figure 1: The Inventory management influence network (IMIN)

A quantification of the IMIN framework has been carried out. To do so, different sets are introduced.

$$T = \{ \quad tools\ t\ introduced\ in\ the\ framework \tag{1}$$

$$F = \{ \quad factors\ f\ introduced\ in\ the\ framework \tag{2}$$

$$R(t) = \{ \quad tools\ required\ to\ implement\ t\}: \forall\ t \in T \tag{3}$$

$$S(t) = \{ \quad tools\ having\ a\ synergistic\ effect\ on\ t\} \forall\ t \in T \tag{4}$$

For this part, *Card(S)* is the cardinality of the set *S*, i.e., the number of elements of *S*. The variable *Imp(t)* indicates how much the tool t is implemented from 0 to 1,

$$Imp(t) = \begin{cases} 1\ if\ the\ tool\ is\ fully\ implemented \\ 0{,}5\ if\ the\ tool\ is\ the\ partially\ implemented \\ 0\ if\ the\ tool\ is\ not\ implemented \end{cases} \quad \forall\ t \in T \tag{5}$$

Tool efficiency value *Eff(t)* has a range between 0 (not efficient) to 1 (considered fully efficient), where $C_t^s = synergistic\ coefficient$ and $C_t^r = requirement\ coefficient$

$$Eff(t) = Imp(t) * C_t^s \quad * C_t^r \forall t \epsilon T \tag{6}$$

The synergistic coefficient represents the importance of the synergy between tools according to a constant.

$$C_t^s = \begin{cases} \alpha * \frac{\sum_{t' \epsilon S(t)} Imp(t')}{card(S(t))} + (1-\alpha) if\ S(t) \neq \emptyset \\ 1\ if\ S(t) = \emptyset \end{cases} \quad \forall\ t \in T \tag{7}$$

The requirement coefficient is defined as illustrated in Eq. 8:

$$C_t^r = \begin{cases} \prod_{t' \in R(t)} Imp(t')\ if\ R(t) \neq \emptyset \\ 1\ if\ R(t) = \emptyset \end{cases} \quad \forall\ t \in T \tag{8}$$

The iindependent factor value does not take into account the influences between factors.

$$V_f^{ind} = \frac{\sum_{t \in M(f)} Eff(t) + \beta * \sum_{t \epsilon m(f)} Eff(t)}{\mathrm{Card(M(f))} + \beta * \mathrm{Card(m(f))}} \forall f \in F \tag{9}$$

Dependent factor value does take the influences between factors into account.

$$V_f^{dep} = \begin{cases} V_f^{ind} * (\gamma * \frac{\sum_{f' \epsilon I(f)} v_{f'}^{ind}}{Card(I(f))} + (1-\gamma)\ if\ I(ft) \neq \emptyset \\ V_f^{ind} it\ if\ I(f) = \emptyset \end{cases} \quad \forall\ f \in F \tag{10}$$

A global score of inventory management IM is introduced where 4 stands for the 4 factors employed in the IMIN framework:

$$IM = \frac{\sum_{f \in F} v_f^{dep}}{4} \tag{11}$$

These measurements are based on data gathered in the companies in the supply chain, e.g., quantitative data as well as qualitative input. As such, this is a way to help foster dialogue and subsequent decision regarding the current and desired future state.

METHODOLOGY

This research is explorative and thus the case study approach was selected. The case company was US Healthcare System (a synonym used for anonymity reasons) and their retailers and drug wholesalers. This supply chain was selected due to their need for improved collaboration and knowledge sharing across the supply chain. Data was collected from US Healthcare System, selected retailers (11 hospitals) and a strategic drug wholesaler for US Healthcare Systems. Data was collected through questionnaires (11-21 answers from each company), semi-structured interviews (7-11 interviews from each company), and workshops (1-2 workshops in each company, 4 workshops with representation from all 13 companies involved in this study). All data was checked by several researchers and confirmed by the participants.
US Healthcare System oversees the flow of medications from distributors to 11 hospitals and more than 400 clinics in the USA. They have a Shared Service Centre (SSC) for this purpose. The supply chain is therefore as follows: Drug producers -> Drug wholesalers -> US Healthcare Systems, including their SSC->Retailers, including medical centres, hospitals, and clinics.

RESULTS

The communication between the hospitals and the SSC and SSC and their main drug wholesaler, is mainly done through a shared IT system. Special orders are via other means (e.g., mails, phone calls). Table 2 shows the supply chain tools used in the case.

Tool	**Current situation**
VMI	Implemented between the SSC and two retailers, other hospitals considered.
RFID	A few bar codes are partially used in some points of the supply chain.
Cloud analytics	Not in use. Software is used to make orders and keeping records.
Centralization	Two hospitals have started to reduce inventory by centralizing to the SSC.
Forecasting	The current system does not use advanced forecast techniques.
Portfolio reduction	The products portfolio is decided by the hospitals. There is a program that goes through different medication and find the best one (reduction of product).
Dose banding	Dose banding is not used yet but is considered.
ABC/VED analysis	No categorization technique is currently in use
Lean methods	Some production staff trained in Lean 6 Sigma; some methods applied.
MC simulations	No equivalent of this tool is currently used

Table 2: Current use of tools

To summarize, the challenges are a lack of forecasting methods and tracking systems. Furthermore, 3 different couriers are used, driving time inferior to 1 hour. The SSC uses fixed reorder point, but no methods are employed at the hospitals or at other points in the supply chain.

Using the IMIN framework and the quantitative methods developed for the framework on the case the current state shows there were improvement potential in several areas:

- Visibility (17%): Poor visibility due to limited use of VMI and no use of RFID and cloud analytics.
- Uncertainties (19%): Uncertainties is high as centralization is only being used for 2 hospitals.
- Diversity (29%): Diversity got the highest score due to the use of portfolio reduction techniques.
- Lead time (26%): Lead time score were due to some applied lean methods.

This gives a combined inventory management score of 20%. To aid communication and avoid misunderstandings, the results were also drawn up and shown graphically, using Figure 1 as a starting point.
Using the framework to determine a future state, the stakeholders assessed the different tools according to 3 criteria: importance, maturity, and implementation difficulties (see Table 3). The rating was from

one to three stars, with ***, being the highest score (e.g., a 3 star rating for implementation difficulties meant the tool being evaluated was extremely costly, time-consuming/difficult to implement).

#	Factor	Tool	Description	Importance	Maturity	Implementation difficulty
1	Visibility	VMI	Vendor Managed Inventory	***	***	**
		RFID	Trackability System	***	*	***
		Cloud analytics	Big Data Analysis	***	*	***
2	Uncertainties	Forecast	Use of specific forecast methods for each product according their ABC/VED analysis	***	***	**
		Centralisation	Reducing the customer inventories to play more on a big central inventory	***	***	**
3	Lead time	Lean methods	Reducing waste(time, products) by continuous training and organization improvement	*	***	*
		MC simulations	Use of analytics to predict/act on the variations of lead time	*	**	**
4	Diversity of products	Dose banding	Standardization of Drugs concentration	*	*	***
		Portfolio reduction	More selective choice of medication	*	***	*
		ABC/VED classification	Analysis of product and different inventory policies according to each product volumes/importance	*	***	*

Table 3: Evaluation of the tool categories

The scoring for the framework on the four factors were in the desired future state was: Visibility (99%), Uncertainties (99%), Diversity (83%) and lead time (80%), with a combined inventory management score of 80%. Like for the present state this was also drawn graphically to aid understanding among the stakeholders. A timeline and action plan for implementation was developed and compared to the plans the main actors already had for improving the supply chain (see Figure 2 where the red line is the IMIN action plan, yellow was the action plan developed by US Healthcare System and green shows the action plan for the strategic drug wholesaler. The blue shows the current state for the supply chain. It can be seen that the IMIN action plan shows high visibility, due to the suggested implementation of RFID.

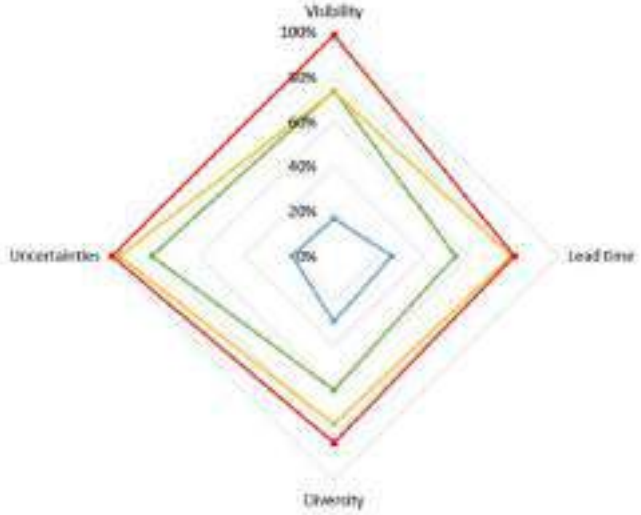

Figure 2: Comparison of action plans

A follow-up workshop a year later, shown that the framework was still being used in the supply chain to ensure continued fit towards a desired future state.

FRAMEWORK APPROACH

The case study showed the applicability of the framework as well as the need for continued adaptation. Figure 3 shows the key implementation steps of the IMIN framework. These are descried in the following.

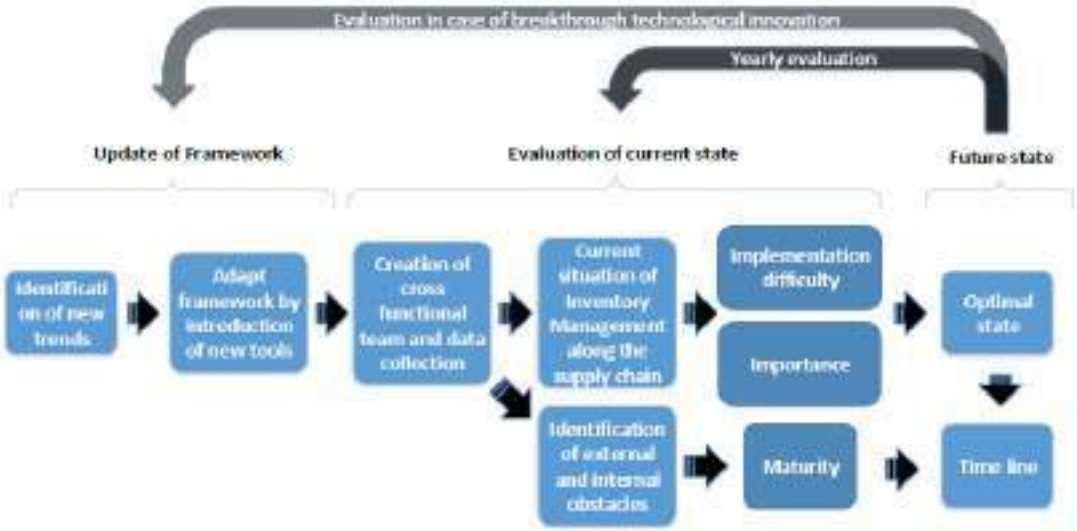

Figure 3: IMIN framework implementation steps

Step 1 - Update the framework
New technologies and techniques should be evaluated to identify which should be added to the framework, relating them to the four factors and the existing tools.

Step 2 - Evaluation of current state
It is necessary to get staff involved from several departments, e.g., supply chain, production, IT. Data collection should if possible be through both quantitative and qualitative means. Hereafter, the current state of the supply chain can be established. External factors should also be considered to determine if these can create obstacles, for example resistance to change as well as the technological and legal limitations.

Step 3 - Future state
The desired future state is decided, with consideration to implementation difficulty, maturity and importance. Thereafter, a timeline and roadmap can be created by taking into account the maturity criterion, finances and other dependencies.

Step 4 - Yearly review
As markets and technologies change and implementation from current to future state is often long (e.g., several years), the framework should be revisited and adjusted yearly.

CONCLUSIONS AND NOTES FOR FURTHER RESEARCH
Collaboration across the supply chain is a prerequisite to create a cost efficient and responsive supply chain. This lack of knowledge sharing in the pharmaceutical industry is in particularly felt regarding inventory management, leading to overstock, stock miscalculations, long lead times and discard of products. Thus, supply chain tools for knowledge sharing to manage inventory levels are a source of competitive advantage if addressed. Existing literature describes causes for inappropriate inventory management and opportunities for improvements using new knowledge sharing technologies and tools. However, an operational framework for practitioners in this industry to help them select tools and frameworks has been lacking. This paper addresses this research gap. First, a literature review was carried out, grouping research into four factors influencing inventory management in this industry. Furthermore, tools and new technologies connected to these factors were detailed. The Inventory Management Influence Network (IMIN) was created to guide companies in their decision-making process to establish the best path to an optimal state of inventory management. The framework's operationality was validated using the supply chain of a US-based drug distributor, some of its retailers and a strategic drug wholesaler.

Further research should perform additional case studies from different countries and with different setups and structures. The framework could be extended to include an in-depth financial aspect and could be digitalized, making updating the framework with new tools and using it, both initially and as a yearly follow-up, faster and easier.

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Exploratory Research on the decommissioning Challenges for oil wells: A case of Gulf of Thailand

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INTRODUCTION AND RESEARCH BACKGROUND

Decommissioning is a complex area presenting many inter-dependent managerial challenges from legal, financial, environmental and operational perspectives. It seeks to balance the needs of sustainable development with environmental protection for future generations, with actions that due to the nature of fiscal regimes, are partially funded by the tax payer. This study examines the challenges that offshore decommissioning faces in particular for the Gulf of Thailand (GoT), where activity is imminent but to date, no fixed platform structures have been fully decommissioned.

Twomey (2010) reported that were 260 fixed offshore structures installed in Thailand GoT waters, more than in Malaysia. Current estimates of fixed GoT platforms are uncertain (different numbers appear in publications) but between 300-400 platforms, none of which have been removed. Of these, the majority are over 20 years old and therefore potentially already in excess of their design life. According to WoodMacKenzie (2016), Thailand will lead regional decommissioning efforts with over 200 plans expected to be submitted for regulatory approval over next three years.

Decommissioning has been examined from a number of perspectives in the literature. Whilst a degree of overlap is evident for some aspects, these have been subsequently presented from four different perspectives: legal, environmental, financial and operational. Available academic literature shows an arguably understandable bias in terms of geographic coverage. Published papers tend to focus the North Sea or Gulf of Mexico ('GoM') where most decommissioning activity has already been completed. Within the SE Asian region, more recent papers have considered decommissioning activities in Australia and Malaysia.

Decommissioning experience is limited within the Thai E&P industry. Exploratory research was undertaken, conducting semi-structured interviews with a selection of key personnel in operating companies, the service sector, and advisory companies. Requests for participation were made at least one representative from every company operating producing assets in the GoT. Whilst relatively small in number, the operating companies whose representatives provided input to this study, are collectively responsible for over 95% of Thailand's offshore production.

Collected data has been qualitatively analyzed by transcribing, codifying and collating according to different issues, and was broadly categorized from a legal/regulatory, financial, environmental, operational and political perspective. These issues were assimilated to identify the major issues, business drivers and conflicts of interest present in Thailand. From this, key challenges for GoT decommissioning were identified before making some recommendations for consideration. The rationale for this paper is to identify the key challenges so that better informed decisions can be made that will enabling more efficient planning and cost-effective implementation of GoT decommissioning activities.

DECOMMISSIONING

One difficulty in regulating offshore decommissioning is the absence of a clear legal definition of "decommissioning" (O'Hara, 2015), as the term is not present in any of the major international legal documents on the subject (Hamzah, 2003). In simple terms, decommissioning is the process of rendering a facility inoperative, which normally entails making it safe by dismantling and decontaminating it. It encompasses the planning, seeking government approval and implementing the abandonment or removal of the structure when it is no longer required (Ahiaga-Dagbui, 2017), and is a broader term than "abandonment" with which is it often interchangeably used. In an oil and gas context, offshore decommissioning involves the safe plugging and abandonment of wells, combined with appropriately dealing with the disused production facilities. A typical offshore platform facility showing the major components is illustrated below. From the definitions and decommissioning activities, it can be easily concluded that decommissioning is a complex activity and requires input from multiple

stakeholders and caution has to be exercised for safe disposal. Following section will provide various perspectives related to the decommissioning activity.

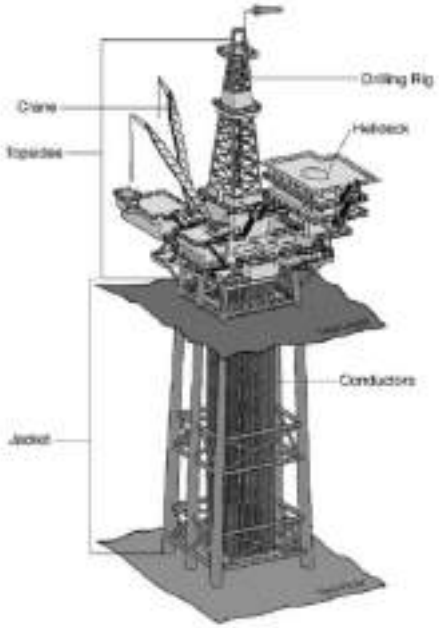

Figure 1: Components of a Typical offshore Platform

Source: Schroder & Love (2012)

DECOMMISSIONING STRATEGY

Decommissioning strategy concerns the choices that made to how to deal with disused facilities. Theoretically, a full spectrum of choices exist from leaving a facility in place and monitoring to total removal but in practice, international/regional/national regulations constrain available decommissioning options. A significant part of the academic debate surrounding decommissioning has been devoted on how to make the choice of decommissioning option that achieves the optimal balance between conflicting areas of cost, safety and technical feasibility. The resulting choice is commonly referred to as the Best Practicable Environmental Option ('BPEO').

Figure 22 shows the potential options for decommissioning offshore facilities. For GoT, shallow water depths and platform weights mean that leaving structures in place is not permitted.

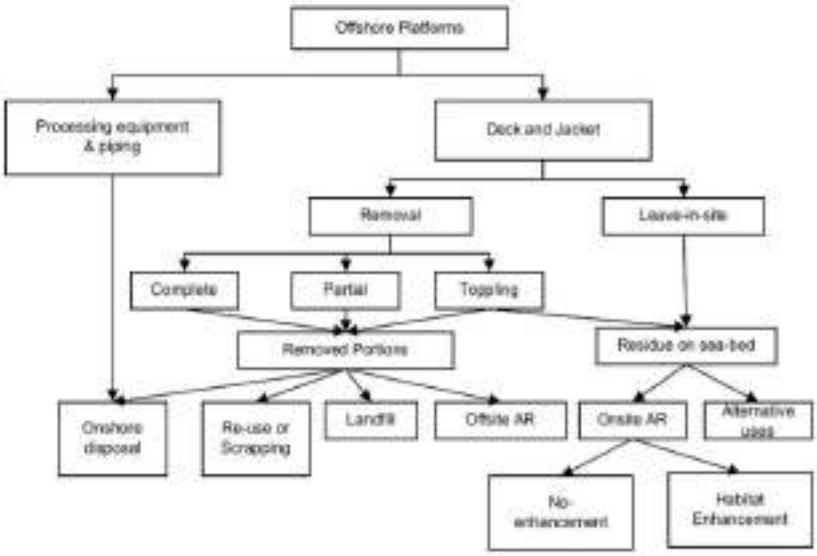

Figure 2: Possible Decommissioning Options for Offshore Facilities

Source: Lakhal et al. (2009)

A number of studies have been devoted to decommissioning strategy. Ekins et al. (2006) was one of the first to make a comparative assessment of different decommissioning scenarios within the scope of existing regulatory frameworks. This included a quantitative analysis of material and energy-flows and financial flows, and a qualitative comparative assessment of the non-financial, especially environmental outcomes of the different scenarios. Building on these ideas, Fowler et al. (2014) proposed a multi-criteria decision framework for evaluating and comparing alternative decommissioning options using selection criteria such as environmental issues, financial case as well as health and safety considerations. In an increasingly sophisticated approach to defining strategy, McCann et al. (2017) integrate decision support models with market and non-market value attributes for platform decommissioning.

Since the controversy surrounding the Brent Spar facility decommissioning by Shell, operators have been subjected to increased environmental group pressures to consider more 'sustainable' decommissioning' practices. Zawawi et al. (2012) are amongst those who have looked at sustainable development options in SE Asia including re-use for commercial developments. Conceptual frameworks for 'sustainable' decommissioning also have been presented by Lakhal et al. (2009) and Lun et al. (2012), and an expert knowledge based decommissioning selection system (Na et al.,2017). Kanmkamnerd et al., (2016) examined the evaluation of different decommissioning aspects through a 'net environmental benefit analysis' ('NEBA'), a semi-quantitative relative ranking scheme that considers "the gains in environmental services or ecological properties achieved by an action minus the impact or injuries caused by that action".

All these approaches recognize the need of place a 'value' on non-financial items as part of the choices are around decommissioning strategy but do so in different ways. The difficulty lies in the non-financial value is dependent on stakeholder perspective, and regardless of method, the choice of the 'best' option always remains subjective to some extent.

Financial Perspectives

The most important aspects of decommissioning financing amount to who pays the bill, how much will it cost and what is the uncertainty with this estimate.

Funding Decommissioning Costs

Decommissioning costs have been increasing over recent years (Boschee, 2014) and despite efforts to reduce costs (Whitfield, 2016) and improve efficiency (Whitfield, 2017) in areas like the North Sea, decommissioning is now a significant board level issue for all major oil and gas companies (Twomey, 2013). Decommissioning liabilities have grown and in 2014, surpassed 10% of the market capitalization of major IOCs (Bardi et al., 2015). Until recently, Thailand had previously no formal mechanism for setting aside costs (Chandler & Kalis, 2017) but the recent legal changes now provides for several methods (WoodMacKenzie, 2016).

Tax Deductibility

Decommissioning costs have a unique consideration in that decommissioning costs can usually be offset against income tax liabilities, making decommissioning relevant to the public as these activities are effectively being subsidized by the tax payer. In the UK, this subsidy can range between 30% and 70% (Ekins et al., 2005) whilst in Norway this is over 80% due to the government's participating interest in state company, Statoil (Climate & Pollution Agency, 2011). Parente et al. (2006) also considered tax deductibility issues from a legal perspective. Whilst this may not have been the originally intended consequence, partial tax payer funding is arguably a good thing since it aligns the interests of the regulator and industry in balancing cost with environmental protection. Although Thai national legislation states that the operator must pay for the decommissioning costs (Thungsuntonkuhn, 2012), the extent to which these costs are tax deductible in Thailand has not been discussed.

Cost Estimation Methods

Decommissioning costs have been referred to as the 'spine' of the decommissioning process (Twomey, 2013) yet their estimation presents a number of challenges. Compared to development projects, decommissioning projects potentially face even greater uncertainties with rapidly evolving

regulatory frameworks, lack of experience and challenging environments (Ernst & Young, 2015). Cost estimation methods tend to rely on benchmarking to existing projects but other approaches have been presented in the literature. Kaiser & Lui (2014) used the work decomposition algorithms to estimate cost elements relating to decommissioning of deepwater fixed platforms and compliant towers whilst Bressler & Bernstein (2015) detailed a mathematical decision model that provides cost estimates for removal of California's offshore platforms

Accuracy/Uncertainty in Cost Estimation

Decommissioning cost estimation accuracy also complicated by factors that include data quality, availability of benchmarking data, time / age of the associated infrastructure.

Twomey (2013) highlighted overruns in the North Sea in excess of this and noted that additional costs can arise from decisions made to defer activities as was the case for decommissioning platforms on the North Sea NW Hutton and Ekofisk fields. Whilst cost estimates are essential for the decommissioning planning process, there is little local data upon which to base cost estimates though the larger operators like Chevron and PTTEP may benefit respectively from their overseas experiences (Wright, 2015).

Operational Perspectives

Operational aspects have received the least attention in academic literature but are considered more in industry and trade journals. These include decommissioning planning and implementation which can be considered primarily as: well Plug and Abandonment ('P&A'), offshore facilities removal (topsides, jacket, pipeline or subsea equipment), transportation to onshore, and dismantling and disposal, including recycling or materials and contaminated waste disposal.

Data Quality and Accuracy

Planning for decommissioning commences with developing an understanding of the current status wells and facilities. Oudenot et al. (2017) have highlighted potential problems with data and information management that include the possibilities of varying types of data and data formats, and data of questionable quality especially on older wells.

Well Plug and Abandonment

For decommissioning, all wells need to be sealed to permanently prevent future hydrocarbon leaks. Oudenot et al. (2017) have highlighted the lack of technical standards across the industry. No single lost cost methodology for plugging wells exists and well P&A standards vary by operator and country. Many operators select P&A designs that go beyond local regulatory compliance. With well P&A typically costing 40%-50% of decommissioning spending, each company's approach plays an important role in dictating overall costs.

Design acceptance criteria differences between installation and decommissioning

Chandler et al. (2017) highlighted that design acceptance criteria should be different and less stringent for decommissioning than for installation. Design criteria for installation, caters for safe operations with producing hydrocarbons and accommodating people, whilst for decommissioning, should only requires that the structure remains sufficiently stable on the sea-bed, and ensures no adverse environmental impact or on other sea users.

Downstream Supply Chain Capacity

Wilby (2011) has described concerns on sufficient decommissioning capacity for the North Sea. With onshore activities effectively commencing from a standstill, Thailand faces similar downstream capacity concerns: sufficient decommissioning yard capacity and contaminated waste disposal capabilities. In the UK, the government has provided funding to ensure that the local supply chain benefits from decommissioning activities, including support for infrastructure upgrades and developing business cases for new yards.

RESEARCH STRATEGY & DATA COLLECTION METHODS

Qualitative methods such as interviews are considered a superior strategy for primary data collection where detailed insights are required from individual participants (Bruce & Berg, 2001). For this

research, semi-structured interviews was selected to gather primary data as the opportunity to use open-ended and probing questions would facilitate a deeper insight into the key issues (Gill et al., 2008). As little GoT decommissioning activity has taken place to date, interviewees were selected based on their level of experience and exposure to decommissioning within their organisation. Those selected generally represented 'key informants' working in responsible and key positions; this 'elite' interview approach was deemed most likely to yield insightful information (Marshall & Rossman, 2011). Participation by company is summarized in Table 1.

Company	Category	Participation	Comments
Chevron	GoT Operator	Invited & Accepted	Interviewed: 24th October 2017
Mubadala Petroleum	GoT Operator	Invited & Accepted	Interviewed: 19th October 2017
Ophir Energy	GoT Operator	Invited & Accepted	Interviewed: 19th October 2017
PTTEP	GoT Operator	Invited & Declined	Offered but failed to provide written answers to questions
CEPSA	GoT Operator	Invited	Failed to respond to two participation requests
Kris Energy	GoT Operator	Not Invited	Due to potential professional conflict of interest
Weatherford	Service Company	Invited & Accepted	Interviewed: 20th October
RESL	Advisory Firm	Invited & Accepted	Interviewed: 20th October

Table 1: Research Study Participation by Company

Data Analysis

Qualitative data analysis methods have been used to examine the primary interview data. The audio recordings were transcribed the content was read, and different themes identified. The data was fractured and reorganized using a combination of *emergent* coding and *a-priori* coding (Wilson, 2014) to enable comparison across different categories. The interview identified a range of issues faced by Thai's offshore industry and the following section provides an overview about the key themes from the interviews.

Decommissioning Challenges: Interviewee Opinions

Five of the interview candidates were asked to nominate their top three challenges based on their experience. Their choices are summarized in Table 2.

Decommissioning Issue	Issue Ranking Importance by Interviewees				
	A	B	C	D	E
Clarity on the Decommissioning Guidelines	1		3	1	1
Contaminated Waste Management	2	3		=3	
Local content/ supply chain capacity	3		2		3
Decommissioning Financing		1	1		
Rig- to-reefs Policy Development		2			
Regulator Capacity & Capability				2	2
Establishing industry forum				=3	

Table 2: Interviewee Selection of Decommissioning Challenges

KEY DECOMMISSIONING CHALLENGES FOR THE GULF OF THAILAND

Decommissioning strategy is dictated by business drivers, but made within the constraints of prevailing regulatory frameworks. For decommissioning, there is there is the law, the interpretation of the law,

and the application of the law. Decommissioning guidelines for comply with legislation but remain subject to interpretation by the regulator. Current guidelines dating from 2009 need to be updated to move towards a more risk-based approach, especially for well P&A, which represents current industry best practice. Any new guidelines should be flexible to accommodate progressive improvements in technology, and an approval process at a lower DMF Director General level without require ministerial approval. Developing risk-based guidelines that provide sufficient flexibility for this application is a key challenge.

Whilst improved guidelines will avoid unnecessary costs, the amount that operators that will ultimate pay remains unclear as the level of tax deductibility levels on decommissioning costs has not been resolved. Balancing a level of a tax relief that benefits industry and most closely aligns interests in BPEO selection, whilst at the same time providing fiscal stimulation to encourage further investment to maximise economic recovery of Thailand's national resources is a key challenge. Continued investment is also tied to end of concession management and way forward that provides a collective win-win for industry and government looks challenging.

The impending wave of decommissioning activity will produce a significant increase in workload for the regulator, particularly if more risk-based guidelines are adopted. This will also occur at the same time as the regulator will be required to administer a transition to more onerous PSC and service contract fiscal regimes whilst continuing with tax and royalty models on existing concessions. Having sufficient people with the enhanced capabilities to manage this increased workload and complexity will be a huge challenge for the regulator.

Fabrication yards are gearing up to win future decommissioning business but without certainty over activity levels to support their business model. These yards do have any experience with dismantling, recycling, or disposal of contaminated waste. The downstream decommissioning value chain sector faces a significant learning curve challenge in operations and in managing the challenging patchwork of regulations on contaminated waste management.

This study set out to identify the key challenges for GoT decommissioning. Challenges can arise both from conflict and a shortage of resources. Based on a consideration of input from literature, interviews and analysis these are as follows:

Perspective	Key Challenge
Legal	Develop a more risk-based, flexible set of decommissioning guidelines
Political	Develop enhanced regulator capacity and capability to manage the impending volumes of decommissioning applications requiring review and appoval
Financial/Political	Resolve uncertainty over tax deductibility to align government and industry interests for BPEO selection
Political/Legal	Resolve difficulties surrounding funding for and the transfer of liabilities for end of concession management
Environmental/Political	For rigs-to-reefs policy implementation, secure stakeholder support in the public consultation process and government agency support for liability transfer from operators
Operational	Develop downstream decommissioning yard capacity through business model support and organisational systems for tracking and inventory management of contaminated waste
Environmental/Legal	Simply patchwork of environmental regulations on contaminated waste management
Legal/Political	Inter-government acceptance of liability transfer for artificial reefs

Table 3: Key Offshore Decommissioning Challenges for the Gulf of Thailand

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The limitations of electric cargo bikes – a systematic literature review

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INTRODUCTION

Electric cargo bike (ECB) is treated as a promising alternative fleet to the conventional vans (Švadlenka et al., 2020) because of its lower environmental impact (Shahmohammadi et al., 2020; Enthoven et al., 2020), easy access to restricted zones, high efficiency in densely inhabited areas (Ramírez-Villamil et al., 2022), and savings regarding to parking, etc (Anderluh et al., 2016; Elbert & Friedrich, 2020; Caggiani et al., 2020; Alewijnse & Hübl, 2021). On the other hand, the adoption of ECBs is also restricted by its vehicular limitations such as loading capacity, battery, and riding speed, etc. (Thoma & Gruber, 2020). Before real application, a comprehensive understanding of the characters of ECBs is crucial, especially from the perspective of its drawbacks. In addition, by linking each drawback together, the hidden interacting mechanism between each drawback is appear, which provides a deeper insight into each connected single drawback. From the literature, the drawbacks of ECBs are only briefly mentioned and without being supported by statistics. Besides, the relationships between these drawbacks are vague.

The aim of this paper is to discern the knowledge from the literature by conducting a systematic review to provide ECB users with insight into the limitation of ECBs that affect their penetration and the relationships among these limitations. To our best knowledge, this study is the first paper to investigate the interacting mechanism among the limitation of ECBs, which enriches the knowledge of ECBs on the existing relevant literature and provides stakeholders with theoretical support for the understanding and decision-making on the adoption of ECCs, potentially reducing the concerns and reservations against the adoption of ECCs.

This paper is structured as follows: the objectives and the methodology; followed by the bibliometric review including the year, source, and region of the selected papers; together with the identification of the ECBs' limitations and their relationships; and finally, conclusions and the major research gaps are proposed.

METHODOLOGY

Phase 1: literature search

1) Classification context – the focus of the analysis is on the limitations that affect its penetration.

2) Unit of analysis – single scientific paper published in scientific journals, conference proceedings.

3) Snowball sampling – at the beginning of the process, 5 papers are referred by research team members to get started. The information about the paper for snowball sampling are below:

Citation	Year	Source	Source type	Country
Koning & Conway, 2016	2016	Case Studies on Transport Policy	Journal	France
Rudolph & Gruber, 2017	2017	Research in Transportation Business & Management	Journal	Germany
Gruber & Narayanan, 2019	2019	Transportation Research Record	Journal	Germany
Thoma & Gruber, 2020	2020	Transportation Research Procedia	Conference proceeding	Germany
Pérez-Guzmán et al., 2022	2022	Transportation Research Part A	Journal	US

Table 1. Papers for snowball sampling

4) Search protocol – through forward and backward referencing, 10 key words of "cargo bike(s)", "cargo-bike(s)", "electric cargo bike(s)", "E-cargo bike(s)", "city logistics", "deliver(y/ies)", "freight(s)", and "last-mile" are selected to conduct a further systematic search on the database - Scopus.

5) Filter setting - Moreover, only articles published in English and in final stage were considered.

6) Exclusion criteria -17 papers (appendix table 1)are excluded according to the criteria below:

Exclusion criteria	Citation	Exclusion criteria	Citation
Vehicle design	Bogdanski et al., 2021	Wrong vehicle type	Rajesh & Rajan, 2020
	D'Hondt et al., 2022		Bieliński & Ważna, 2020
	Groneberg et al., 2021		Starczewski, 2020
	Hogt et al., 2017		Nascimento et al., 2020
Mobility	Baum et al., 2019	Different research area - land consumption	Schnieder et al., 2020
	Ehrhardt, 2016	Different research area - consolidation facilities	Assmann et al., 2019
	Serrano-Hernandez et al., 2021		Fikar & Gronalt, 2018
Sharing economy	Hess & Schubert, 2019		Kijewska & Iwan, 2019
	Perboli et al., 2022		

Table 2. Exclusion criteria

7) Scope definition – together with the 5 papers for snowball sampling, 65 papers published from 2014 to 2023 relating to the application of electric cargo bikes in the field of urban logistics are selected out of 77 papers for further research.

Phase 2: literature analysis

Papers will be analysed from bibliometric and conceptual aspects respectively. The year of publication, region/country, and the source title will be summarised first. Then, papers will be analysed by content. The analysis process will be conducted by cross-checking among other authors to ensure the work is unbiased.

BIBLIOMETRIC REVIEW

In terms of the years of publication, from 2014 to 2019, cargo cycle deliveries had gained limited attention and interests from the academic and practical sections. The remaining 51 papers are published from 2019 to 2023. This may be due to the realisation of the noticeable advantage of ECBs from both academics and practitioners.

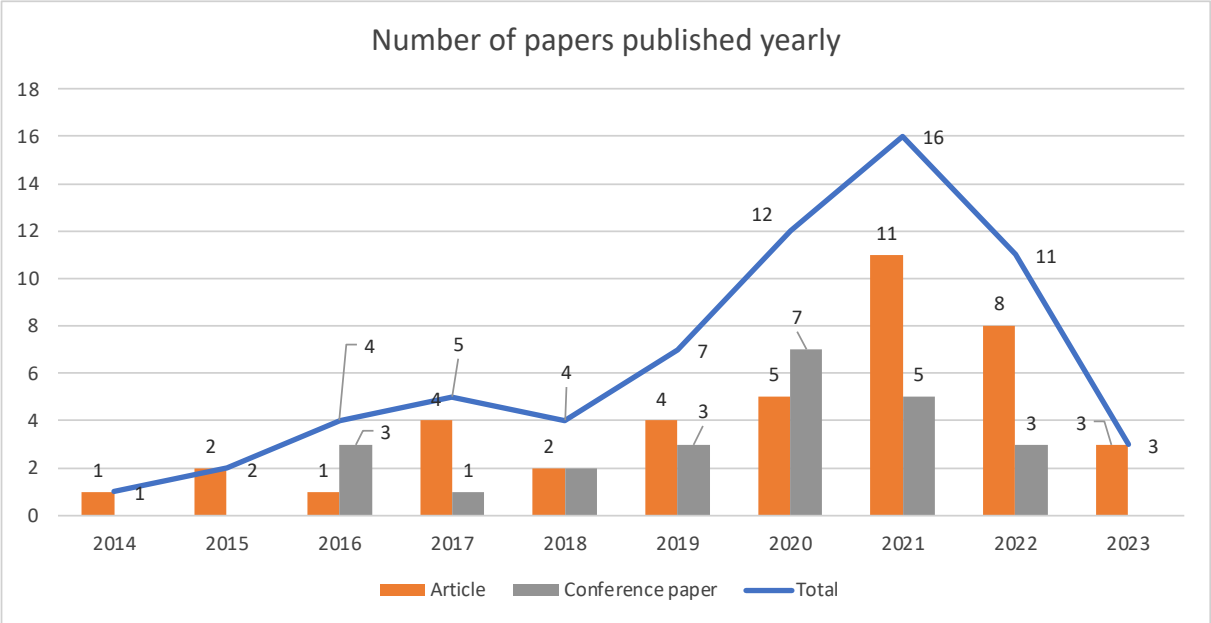

Figure 1: The number of papers published yearly categorised by different resource type.

In terms of the countries (Figure 2), this topic was mostly developed in Germany (17). This may because most of the top logistics companies in the world such as DHL, DB Schenker, UPS, and FedEx are from these two countries. Also, these logistics companies are inspired by and leading the trend of green logistics with enough resources to trial new logistics concepts. In addition, Germany has highly developed infrastructures, high-tech warehouses and the most developed logistics network that is ahead of most European countries. The second largest contribution to this topic is by the USA (11), followed by Poland (5), Italy (5), and France (4). The rest of countries have less contributions than 4.

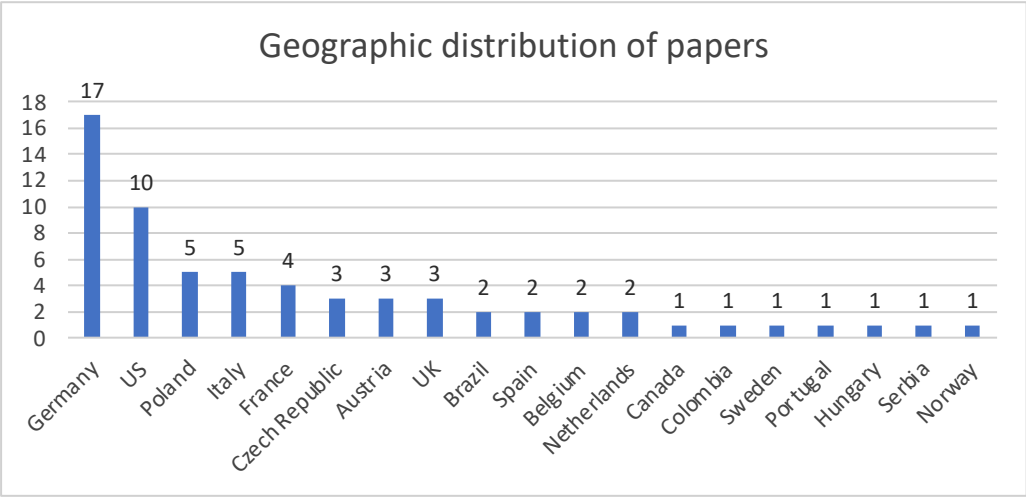

Figure 2: Number of papers published in different countries

In terms of the sources of the selected papers (Table 3), scientific journals (41), proceedings of international conferences (24) are found. Among the scientific journal papers, half of the papers (17/34) were published in journals pertaining to the field of transportation, followed by energy and sustainability (9), and computing and operations (5).

Type	Journals	Count	Sum
Transportation	European Transport Research Review	4	22
	Transportation Research Part A: Policy and Practice	3	
	Transportation Research Interdisciplinary Perspectives	2	
	Research in Transportation Business and Management	4	
	Case Studies on Transport Policy	3	
	Transportation Research Record	2	
	Transportation Research Part C: Emerging Technologies	1	
	International Journal of Sustainable Transportation	1	
	Journal of Transport Geography	1	
	Journal of Transportation Engineering Part A: Systems	1	
Energy and sustainability	Energies	5	11
	Sustainability (Switzerland)	4	
	Environmental Science and Technology	1	
	Green Energy and Technology	1	
Computing and operations	Computers and Operations Research	2	5
	Central European Journal of Operations Research	1	
	European Journal of Operational Research	1	
	Advances in Intelligent Systems and Computing	1	
Applied sicence	Applied Sciences (Switzerland)	2	3
Logistics	International Journal of Logistics Research and Applications	1	

Table 3. the title of paper sources

THE IDENTIFIED LIMITATIONS OF ECBS AND THEIR RELATIONSHIPS

Limited payload capacity

The payload of ECBs indicates both the capacity in weight and in volume. The weight capacity varies depending on different vehicle configurations (Table 4). For example, the weight capacity for cargo bikes, trailers, trikes, and quad ranges from 24-300kg, 32kg-60kg, 100-600kg, and 150-300kg respectively. Also, the threshold weight capacity of cargo trikes and quads is higher than that of cargo bikes, but the weight capacity of different vehicle types overlaps to some extent.

Parameter	Vehicle type	Result	Citation	Vehicle type	Result	Citation
Payload in weight	Bike	50kg	Perboli & Rosano, 2019	Bike	250kg	Fraselle et al., 2021
		70kg	Johnson & Chaniotakis, 2021		300kg	Taefi et al., 2015
		80kg	Caggiani et al., 2021		300kg	Temporelli et al., 2022
		100kg	Fikar et al., 2018		50-75kg	Nürnberg, 2019
		100kg	Sárdi & Bóna, 2021		50-100kg	Vasiutina et al., 2022
		100kg	Bayliss et al., 2022		50-120kg	Naumov & Pawlus´, 2021
		120kg	Schünemann et al., 2022		150-300kg	Choi et al., 2021
		125kg	Sheth et al., 2019	Trike	250kg	Clausen et al., 2016
		150kg	Naumov, 2021		272kg	Sheth et al., 2019
		150kg	Naumov et al., 2020		500kg	Nürnberg, 2019
		150kg	Vasiutina & Naumov, 2021		500kg	Naumov & Pawlus´, 2021
		180kg	Hofmann et al., 2017	Quad	150kg	Dybdalen & Ryeng, 2021
		200kg	Robichet et al., 2022		300kg	Aiello et al., 2021
		250kg	Anderluh et al., 2019;			

Table 4: Payload capacity of ECBs in weight

For the volume capacity (Table 5), both the cubic meter of the storage chamber and the number of parcels the chamber can store are used to indicate volume capacities. The cargo bikes' capacity varies from 1000L-1750L (16-50 parcels). The volume capacity of one type of cargo trike and cargo quad is 2500L and 1000L respectively. Similar to weight capacity, the volume capacity does not show an obvious increase with the increased number of wheels.

Parameter	Vehice type	Result	Citation	Vehice type	Result	Citation
Payload in volume	Bike	245L	Sárdi & Bóna, 2021	Bike	40 parcels	Assmann et al., 2020
		1000L	Hofmann et al., 2017		40 parcels	Alewijnse & Hübl, 2021
		1000L	Bayliss et al., 2022		40 parcels	Büttgen et al., 2021
		1750L	Temporelli et al., 2022		40 parcels	Kania et al., 2022
		16 parcels	Anderluh et al., 2017		40-50 parcels	Niels et al., 2018
		20 parcels	Llorca & Moeckel, 2020;	Trike	2500L	Clausen et al., 2016
		20 parcels	Llorca & Moeckel, 2021	Quad	1000L	Aiello et al., 2021
		40 parcels	Sheth et al., 2019;			

Table 5: Payload capacity of ECBs in volume

Compared to conventional vans/trucks, payload capacity of ECBs only account for 15%-20% that of conventional vans (Kania et al., 2022). Although ECBs have a noticeable advantage regarding their small size, which enables them to park on narrow streets without causing traffic jam (Seeck & Engelhardt, 2021) and to manoeuvre in historical city centres (Ledvinová & Seidlová, 2019; Castillo et al., 2022), this advantage also become one of the major drawbacks of limited payload capacity (Seidlová & Ledvinová, 2020; Naumov & Pawlus´, 2021). The effect of limited capacity is substantial, especially when the customers are widely dispersed (Boysen et al., 2023).

As one of the significant barriers to implementing the bike distribution system, limited load capacity could force the bikes to be stored closer to final customers (Chiara et al. 2023) to avoid rendering the routing inefficient (Arnold et al., 2018). With limited payload capacity either in weight or volume, the variety of packages ECBs can transport and which supply chain they can be part of will be restricted (Dybdalen & Ryeng, 2021). For example, the small payload restricts cargo bikes purely to courier work

such as documents and small dimension parcels (Schliwa et al., 2015; Nürnberg, 2019; Rai et la., 2019). Additionally, extremely heavy packages are not suitable for cycle deliveries either (Rajendran & Harper, 2021).

Although some electric cargo bikes' capacity is comparable with the capacity of light commercial vehicles (Naumov, 2021), optimising space-saving loading and packing operations are even more important than conventional transportation modes in urban logistics (Naumov & Pawlus´, 2021). The low use of vehicle capacity will reduce the effectiveness of last-mile logistics (Bosona, 2020), and the size and weight of goods to be delivered compared to the payload capacity become a crucial factor for the cargo cycles operations (Giglio et al., 2021). A trade-off between payload capacity and flexibility needs to be considered because designing for maximum payload could lead to compromises in the friendly character and manoeuvrability of ECBs (Moolenburgha et al., 2020).

Limited battery range

From the literature (Table 6), the battery range for electric cargo bikes ranges from 19-100km, while only one study states that the range for an electric cargo trike is 20km. The battery range currently aimed at by most manufacturers is between 50 and 100 km (Schier et al., 2016), while 90% of delivery tours travelled by ECBs are up to 75km (Gruber et al., 2014). However, short range is still a limitation of ECBs (Naumov & Starczewski, 2019) as the achievable battery range depends on many factors such as battery size, the number of stops, payload, degree of acceleration, riding style, and topography and weather (Schier et al., 2016; Schünemann et al., 2022). With limited battery range, ECBs can only serve a relatively small area on a single charge (Naumov & Pawlus´, 2021) and its adoption will be affected by this (Giglio et al., 2021; Fraselle et al., 2021).

Type	Range	Year	Citation	Type	Range	Year	Citation
Bike	100km	2015	Taefi et al., 2015	Bike	100km	2021	Naumov & Pawlus´, 2021
	100km	2017	Fikar et al., 2017		20km	2022	Kania et al., 2022
	90km	2018	Sárdi & Bóna, 2018		25-30km	2022	Schünemann et al., 2022
	19-40km	2019	Sheth et al., 2019		60km	2022	Temporelli et al., 2022
	90km	2021	Sárdi & Bóna, 2021	Trike	20km	2016	Clausen et al., 2016
	80km	2021	Büttgen et al., 2021				

Table 6: Battery range of different types of ECBs

Limited speed in free-flow traffic

The average speed of ECBs ranges from 10 to 24km/h in the literature (Table 7). Although there is no regulation restricting the volume, weight and the type of the payloads a ECB can carry, the maximum riding speed and power are limited up to 25km/h and 1000W respectively (Gonzalez-Calderon et al., 2022). The deployment of cargo bikes can worsen speed and increase delay times (Assmann et al., 2020).

Average speed	Citation	Average speed	Citation
10km/h	Aiello et al., 2021	20km/h	Llorca & Moeckel, 2021
12km/h	Arnold et al., 2018	20km/h	Perboli et al., 2022
15km/h	Dybdalen & Ryeng, 2021	24km/h	Bosona, 2020
15km/h	Sárdi & Bóna, 2018	24km/h	Alewijnse & Hübl, 2021

Table 7: Average riding speed of ECBs

Long charging time

The recharging time is also a substantial limitation of ECBs (Aiello et al., 2021). As Sheth et al. (2019) mentioned, it takes 6-8 hours to fully charge the battery.

Inability to hilly terrain

In some hilly area, ECB faces the inability in climbing steep slops (Sheth et al., 2019; Bosona, 2020).

Defection/malfunctions

ECBs will suffer from insufficient quality of cargo cycles' components (Rudolph & Gruber, 2017), such as the battery, motor, and powertrain malfunctions (Vasiutina et al., 2021), which is probably due to some built-in components are designed originally for recreational riding so that cannot withstand the additional payload (Nürnberg, 2019). In addition, the high load on ECBs will shorten their lifetime as well (Pérez-Guzmán et al., 2022).

The relationship among these limitations

As can be seen from figure below, some of the barriers are closed connected with each other.

Figure 3. The relationship among vehicle-related barriers that affect the adoption of ECBs

In terms of the payload capacity, maximum payload could lead to the compromise in the manoeuvrability of ECBs (Moolenburgha et al., 2020). In addition, heavily payloads can impact both the top speed of ECBs (Naumov & Pawlus´, 2021) and the braking distance of ECBs (Rudolph & Gruber, 2017). On the other hand, limited payload capacity can result in the requirement of frequent transhipment, which further increases the distance travelled per item delivered (Arvidsson & Pazirandeh, 2017; Assmann et al., 2020). For battery range, as the battery range will be constrained when operating in topographically moved areas (Choi et al., 2020), the limited battery range will negative affect the abilities in operating in hilly terrains.

What's more, achievable payload and achievable battery range are closed related. Both limited payload capacity (Büttgen et al., 2021) and battery range (Clausen et al., 2016; Koning & Conway, 2016) can both lead to the increased number of required bikes, which can further increase the purchasing cost and maintenance cost of implementation ECBs. In addition, both the increased payload and battery range can increase the maintenance cost of ECBs, but in different ways. The increased payload can shorten the lifetime of ECBS (Pérez-Guzmán et al., 2022) as some of the bikes that are originally designed for recreational riding are not capable to withstand the increased payload and will suffer from malfunctions (Nürnberg, 2019; Lachapelle et al., 2021). In terms of the battery range, although battery substitution in the middle of the e-cargo bike's lifetime does not affect this vehicle's better performance (Temporelli et al., 2022), the larger the battery range, the more expensive it is. No matter how big the battery capacity is, the battery needs to be replaced when reaching the charging cyclical lifetime (500-1000 charging cycles) (Schünemann et al., 2022; Sheth et al., 2019). If the maintenance cost cannot be well controlled, even with low purchasing cost, the wide adoption of ECBs will not be guaranteed (Narayanan et al., 2022).

On the other hands, the payload and battery range can be mutually constrained. The achievable battery range will be significantly affected by payload. More specific, the energy consumption of the powertrain can double from 0.783kWh for the empty payload to 1.447kWh for the full payload (Fraselle et al., 2021). In turn, the maximum payload in weight during operation will be restricted by the battery range (Melo & Baptista, 2017; Gruber & Kihm, 2016; Aiello et al., 2021). In addition, the battery capacity is not the bigger the better. Although increasing the battery capacity allows for longer delivery routes, it also reduces the available payload due to the battery's weight occupancy, therefore reducing the number of serviceable clients (Aiello et al., 2021).

For the riding speed, due to the power limitation (250W) of ECBs (Aiello et al., 2021), the acceleration and top speed are highly dependent on vehicle payload (Naumov & Pawlus´, 2021). In some situations, loading more than three-quarters of the available loading capacity will substantially slow down the riding speed (Gruber & Narayanan, 2019). On the other hand, the impact of payload on riding speed can be totally different when ECBs riding on downhills. The previous resistance will be turned into power, so that the speed of ECB will increase when going downhill, resulting in a longer braking distance (Dybdalen & Ryeng, 2021).

CONCLUSIONS

This study reviewed 65 academic papers from both scientific journals and international conference proceedings. At first, the bibliometric analysis considering the year of publication, region, and source were conducted to understand the general characteristics of the selected papers. By doing this, we found that the yearly number of contributions increased significantly from 2018. What's more, more than half of the papers were published in scientific journals and most of them is relating to the topic of transportation. In addition, nearly one-third of the publications were oriented in Germany and USA are the most developed countries implementing ECBs.

During the conceptual review process, 6 limitations of ECBs are identified from the literature. Afterwards, the relationship among these factors is also summarised. Among all the identified limitations of ECB, payload and battery range have the same effect on certain variables, such as both increased maintenance costs and the total number of vehicles required. On the other hand, they are also a pair of mutually restraining variables. In addition, too fast or too slow speed will also have an important impact on the operation of ECBs. The performance of ECB in mountainous areas is mainly affected by the battery, vehicle speed, and payload. The total design weight of the vehicle is not only determined by the cargo capacity but also affected by the battery size: the larger the battery capacity, the heavier the self-weight.

This review offers insights to both academics and practitioners. From an academic perspective, this work is the first to summarised and analysed the existing relevant literature regarding relationship among identified limitations of cargo cycles in the logistics field. From another perspective, the findings from this study provide logistics service providers with a theoretical support for decision-making, deployment, and application, which enables LSPs to have a better understanding and clear judgement on the adoption of ECBs.

RESEARCH GAPS AND FUTURE DIRECTIONS

The literature on the adoption of ECBs in logistics contexts is still growing. However, several research gaps deserve further study. Firstly, in addition to vehicle-related barriers, other factors from environmental, infrastructural, perception, and regulation perspectives can also affect the adoption of ECBs. And the relationship between different factors belonging to different aspects is still not clear. Therefore, there is a need to conduct a further review regarding a comprehensive framework of the factors affecting the adoption of ECBs and their relationships with each other. By doing this, potential ECBs users can have a more comprehensive understanding of the feasibility of adopting ECBs depending on their specific situation. Afterward, in terms of the battery range, although some of the literature mentioned that ECBs can travel 50-70km depending on a single charged battery, it is still rated as the second important factor of adopting ECBs. However, there is seldom information about whether this battery range is a nominated battery range or an achievable battery range. This piece of information is crucial as the achievable battery range is largely affected by the external environment and usage

scenarios. Hence, company-specific environmental effects on the achievable battery range should be researched further in the future.

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APPENDIX

Title	Authors	Year
Sustainable mobility for Berlin - Green.Smart.Digital.	Ehrhardt F.	2016
Designing light electric vehicles for urban freight transport	Hogt R., Balm S., Warmerdam J.	2017
Agent-based simulation of restaurant deliveries facilitating cargo-bikes and urban consolidation	Fikar C., Gronalt M.	2018
A conceptual framework for planning transhipment facilities for cargo bikes in last mile logistics	Assmann T., Bobeth S., Fischer E.	2019
The implementation of environmental friendly city logistics in South Baltic region cities	Kijewska K., Iwan S.	2019
Functional perceptions, barriers, and demographics concerning e-cargo bike sharing in Switzerland	Hess A.-K., Schubert I.	2019
State of the art - Automated micro-vehicles for urban logistics	Baum L., Assmann T., Strubelt H.	2019
Analysis of Transport Process' Costs with Use Various Technologies in Terms of Last Mile Delivery Problem	Starczewski J.	2020
Characterization and analysis of the economic viability of cycle logistics transport in Brazil	De Oliveira Leite Nascimento C., Rigatto I.B., De Oliveira L.K.	2020
Review and development of a land consumption evaluation method based on the time-area concept of last mile delivery using real delivery trip data	Schnieder M., Hinde C., West A.	2020
Sustainable performance of cargo bikes to improve the delivery time using traffic simulation model	Ben Rajesh P., John Rajan A.	2020
Electric scooter sharing and bike sharing user behaviour and characteristics	Bieliński T., Ważna A.	2020
The Urban Freight Distribution in Medium Size Cities: Descriptive Data Taken from Pamplona (Spain) and Angers (France)	Serrano-Hernandez A., Gougeon T., Cadarso L., Juan A.A., Faulin J.	2021
Transfer of Knowledge and Algorithms from Interdisciplinary Fields of Research to the Measurement of Cargo Without Process Interruption	Groneberg M., Hünermund M., Schütz A.	2021
Development of a General Specification Sheet for Heavy-Duty Cargo Bikes	Bogdanski R., Cailliau C., Seidenkranz M., Bayer M., Reed M.	2021
A Simulation-Optimization Approach for the Management of the On-Demand Parcel Delivery in Sharing Economy	Perboli G., Rosano M., Wei Q.	2022
DEVELOPMENT OF AN ELECTRIC TRICYCLE FOR SERVICE COMPANIES AND LAST-MILE PARCEL DELIVERY	D'Hondt J., Juwet M., Demeester E., Slaets P.	2022

Appendix table 1. Excluded papers.

Supply Chain Analytics

Data-driven supply chain analysis - Development and potential analysis of a model-based damage prediction approach and its integration into SCM

Jens Eschenbächer[1], Jost Wiethölter[2], Linus Kühl[3,4]
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ABSTRACT
Against the setting of an increasing need for innovation and low margins, companies in the logistics sector are facing highly competitive pressure. One field with high potential for optimization lies within damage quotas. The use of big data analytics or data mining represents a promising approach to face this challenge. However, within supply chain management, data mining is hardly being researched on regarding damage quotas and thus not being utilized to its full possible extend. At the current time it seems to predominantly be used for route and utilization optimization while the analysis of delivery damages is hardly considered.

The aim of this research is therefore to showcase an initial approach for data mining in logistics to predict delivery damage probabilities and to validate this by means of a multiple case study research. To create a sound basis for evaluation, the groundwork is laid out based on CRISP-DM by the analysis of reference data (German road-cargo market).

As a central result it is noted that data mining can systematically be used to help reducing the damages by forecasting the probabilities of damages occurring during transport in dependence of different factors. The approach can be utilized across different markets as long as sufficient data tracking delivery damages is being collected within a company. Challenges arise in the field of air- and sea-freight.

INTRODUCTION
The usage of big data analytics has become increasingly important in the business world throughout the last years because of the high potentials such as improving profit and customer satisfaction (Raman et al., 2018). However, in the logistics industry this topic is not yet as widespread as it is in other sectors such as banking or retail (Lamba & Singh, 2017). Currently most of logistics providers are collecting huge amounts of data from their shipments tracking origin, destination, size, weight, content and more (Lekić et al., 2020). However, it is highly questionable whether or not companies are exploiting their data to a full extend – most likely enormous potential is untapped (Lekić et al., 2020). Thus, the field big data analytics represents a possible differentiation criterion compared to other logistics companies. The biggest challenge here is not to collect the data but to use and analyze it systematically while also creating know how and providing adequate IT-tools for usage within the own company (Muntzke, 2016).

In the current literature and empiricism, big data analytics in relation to logistics contexts is mainly associated with optimization of routes, improvement of utilization and less empty runs (Muntzke, 2016). The focus is especially on optimizing the last mile, as this is associated with particularly high costs (Lekić et al., 2020).

However, successful supply chain management involves far more disciplines than those that are currently the focus of big data analytics (Nguyen et al, 2018). According to the 7-R rule, logistics service providers pursue the goal of delivering the right product, in the **right condition**, at the right time, to the right place, in the right quantity, with the right flow of information, for the right costs (Rushton et al., 2022). Also, in line with the quest for perfect order fulfilment to satisfy customers, the focus is amongst other aspects on **damage-free deliveries** (Nur Sholeh & Suwarto, 2020). A consideration of this aspect (right condition/ damage-free deliveries) in connection with big data analytics is hardly dealt with in the literature and in practice. The reason for this is that delivery damage is often regarded and accepted as a necessary operating cost (Denizhan & Alper Konuk, 2013).

Nevertheless a detailed observation of delivery damages against the current trend/ lack of research seems reasonable since the most common reason for returns causing reverse logistics costs is in fact damaged goods (UPS, 2019). The application of a systematic data mining approach on already existing data in order to identify and forecast influencing factors and probabilities for the occurrence of delivery damages could entail significant changes in cost structures for logistics companies.

State of the art and research gap – forecasting of delivery damages in logistics:
As mentioned in the previous section the potential of data mining is not being used to its full extend in the logistics industry - especially with regard to the prognosis/ forecast of delivery damages in dependence of different factors. To assess the current state of the art throughout literature, a comprehensive literature review following the framework by vom Brocke (2009) is carried out. In order to clearly define the scope of the review, the taxonomy presented by Cooper (1988), highlighting suitable aspects for this review as shown in tab. 1, is used.

Characteristic		Categories			
1	Focus	Research Outcomes	Research Methods	Theories	Applications
2	Goal	Integration	Criticism	Central Issues	
3	Organization	Historic	Conceptual	Methodological	
4	Perspective	Neutral Representation		Esposual of Position	
5	Audience	Specialized Scholars	Genral Scholars	Practioners/ Politicians	Genral Public
6	Coverage	Exhaustive	Exhaustive and Selecetive	Representative	Central/ Pivotal

Table 1: Taxonomy of literature review (following Cooper (1988))

The search for literature is conducted by a keyword search in combination with a parallel review of the sources. Table 2 shows the key words used in the search process applied in the data bases JSTOR, Web of Science and Emerald Insight. Through the evaluation of the titles the number of search results is reduced from over 100.000 to 356 relevant articles. However, after further review of the selected literature it is evident that no article explores the data-based prediction of delivery damages. Main focus areas of current literature are demand forecasting (e. g. Dombi et al., 2018; Hofmann & Rutschmann, 2018; Huang et al., 2021; Yang, 2020), performance forecasting not particularly including delivery damages (e. g. Agrawal & Singh, 2020; Ali, 2022; Wang et al., 2018), route optimization (e. g. Li et al., 2019; Wang et al., 2019) and market development predictions (e. g. Hamdan et al., 2022; Wu et al., 2020) With regards to this research gap, this paper aims to shed light upon this topic by showcasing and reflecting the mentioned approach with its potentials.

Keyword A		Keyword B
Forecasting		Logistics
Predicting	AND	Supply Chain
Prediction		

Table 2: List of Keywords

METHODOLOGY
This paper uses the quantitative analysis of reference data (German cargo market) to assess the possibilities in tool assisted data mining to achieve an increase in knowledge regarding damage probabilities. For this purpose, basic re-quirements have to be evaluated first, as shown in Figure 1. By applying CRISP-DM (standard for data mining) in step 2, the raw data is processed with a systematic approach. The preparation of the raw data is carried out by using Power BI to enable scalability for data sets with varying quality levels. In the next step, the homogenized and processed data is used in RapidMiner to create forecast models for determining the probability of damage based on different factors. These models are then assessed for deployment in the enterprise context. To evaluate the approach in practice and thus to validate the theory, case study research is conducted in the third step. This is done according to Yin's model for explanatory case studies, as this approach is particularly suitable for testing theories (Ridder, 2020). The subject of this case study are two German companies: a medium-

sized tool wholesaler and an international logistics service provider. This allows to evaluate the potential of the approach outlined in this paper.

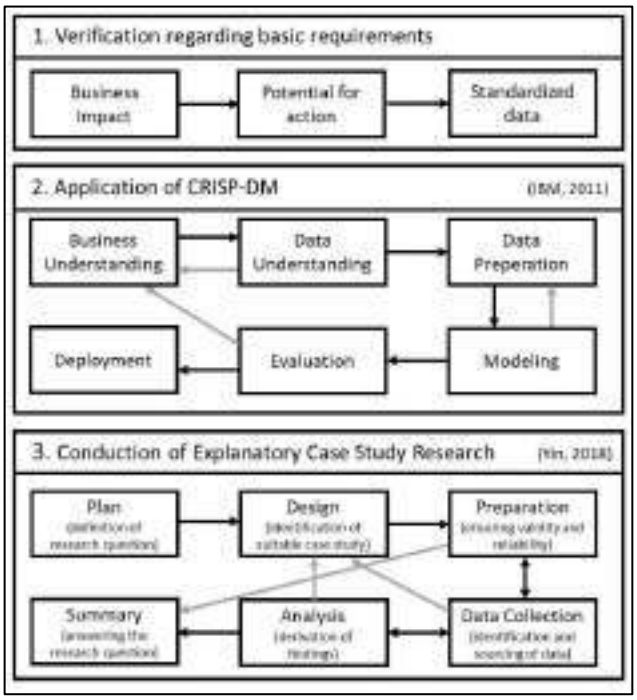

Figure 1: Methodology plan

Verification regarding basic requirements

The business impact of damages has already been explained in the section background and is of high relevance for logistics companies. There are also opportunities for logistics companies to act in response to damages. For example, the service provider carrying out the transport can be changed, the routing can be adjusted, larger shipments can be split up, prices can be changed and transport insurance can be altered. According to ADSp Digit 7.2, information about the transport process must be recorded and stored in a standardized form.

APPLICATION OF CRISP-DM

1. Business Understanding: The primary objective of a logistics service provider is to transport the shipped goods to their destination undamaged. However, the current analysis focus is only on retrospective evaluation of damages that have occurred on a case basis. From this corporate objective results the data mining goal of increasing knowledge regarding factors that increase the probability of damage occurrence. The data used comes from the data warehouse of a freight forwarding company and refers to the German groupage and direct load transport market.

2. Data Understanding: The data used is the data from the operational production systems of a transportation company. The data is plausible against the background of business understanding after exploratory analysis and randomized inspection of a subset. Besides some unfilled fields, the data is well usable as far as it is stored in the system.

3. Data Preparation: To be able to evaluate the data, it must be prepared appropriately. For example, one key challenge was that the reference data of the transport process had two fields for damage. One field for damages before and one field for damages after the transport process. Only those cases are to be considered as damage, in which damage occurs during the transport process. To develop a sustainable approach to condense the information in one field, steps for data cleansing should be automated by using M-Query (Power BI). This is important to be able to evaluate the data adequately because unfiltered data from the operational systems is used. The data from operational systems often show deficiencies in the data quality (Gluchowski & Chamoni, 2016).

4. Modeling: The metadata of the shipment (e. g. which carrier, weight of the goods, number of packages, dangerous goods, handling in the warehouse) are to be used as parameters for the modeling. Based on this, different models were created which will be examined in more detail during the evaluation. The evaluation of the model performance shows that Naive Bayes is the most suitable model for this scenario.

5. Evaluation: The evaluation of the created models has to be done with a comparable metric. For this purpose, the metric AUC (Area Under Curve) is used. Table 3 shows that the Naive Bayes model has the greatest suitability for the given use case. The model performance was measured using a reference data set.

Name	AUC	SD	Rank
Navie Bayes	0.647	0.033	1.
Generalized Linear Model	0.612	0.033	4.
Logistic Regression	0.611	0.030	5.
Fast Large Margin	0.625	0.022	3.
Deep Learning	0.609	0.059	6.
Decision Tree	0.500	0.000	7.
Gradient Boosted Trees	0.636	0.011	2.

Table 3: Model performance

6. Deployment: The last step of CRISP-DM involves planning how to deploy the identified knowledge. Figure 2 shows how integration into the operational workflow is possible. The aim is to use the data to achieve a reduction in the damage quota. To be applicable in practice, this is done by an automated process. An integration of other data sources (e.g. weather & traffic data) is possible. The data is combined using Power BI to create the data set so almost all internal and external data sources can be integrated. The dataset is used by RapidMiner to enable tool-based ex ante damage prediction in two ways.

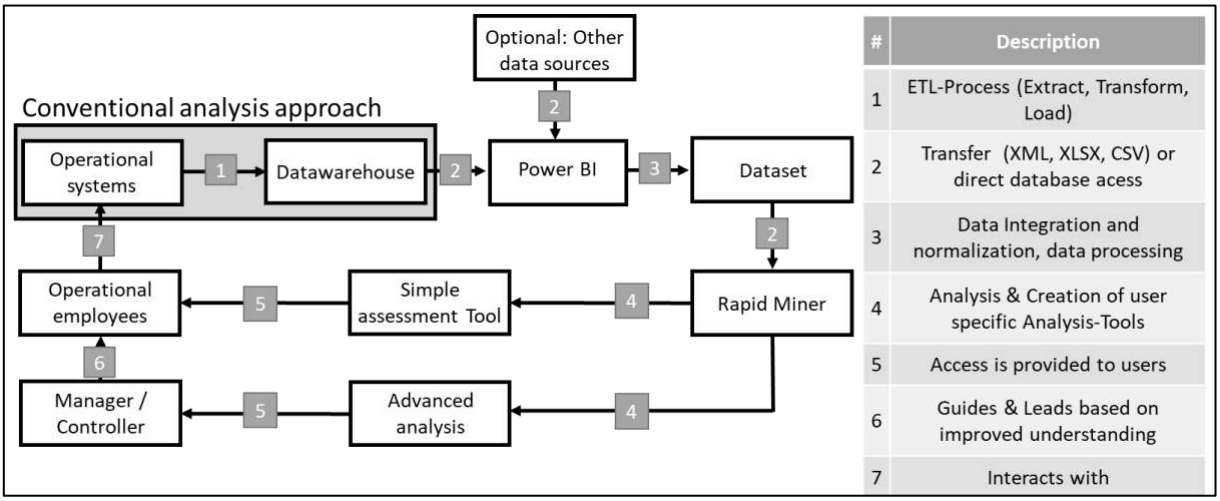

Figure 2: Deployment of the damage prognosis tools.

Firstly, centrally by the company's controlling department to identify problem areas with individual service providers on a high level. Furthermore, drivers for high damage probabilities can be identified and used in a top-down approach to optimize budget planning. A better view of the influencing factor of damage becomes possible. Because this is a complex task, a tool that is easier to use for the user has to be deployed to enable an integration of the knowledge directly into the operational dispatching process. One possibility is the use of a simulator in which the dispatcher only must enter the metadata of the transport, whereupon the result is a predicted probability of damage. Controlling can determine

a threshold value from which a surcharge for increased damage probabilities is to be calculated. This tool is shown in figure 3 on the next page. This bilateral approach enables the integration of knowledge on different organizational levels and thus enables the company to become a data driven enterprise.

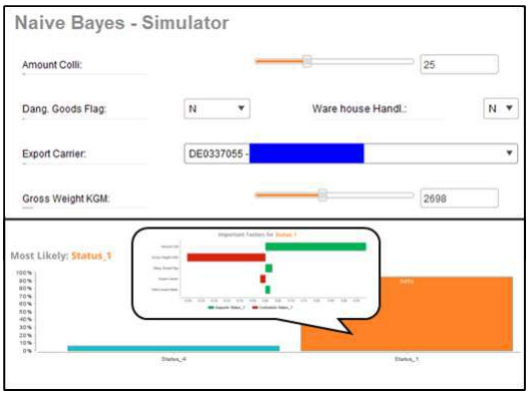

Figure 3: Naive Bayes based simulation tool

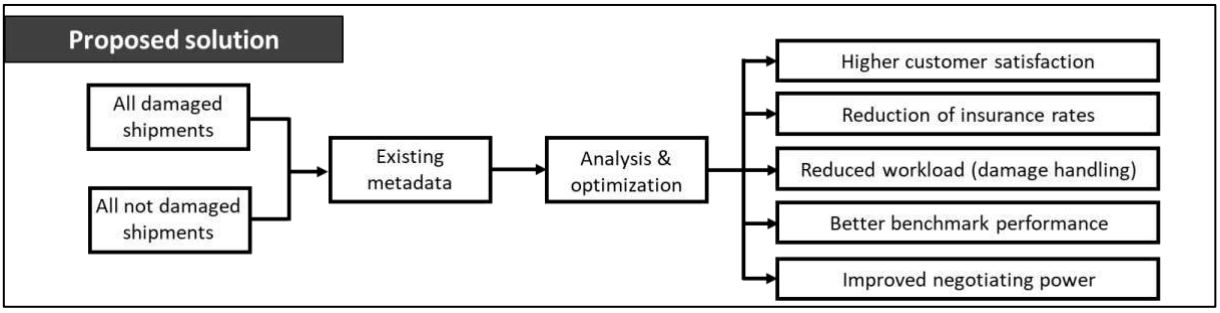

Figure 4: Impact of the proposed method on certain business aspects

Figure 4 shows the potential of the developed model & process for implementation. This differs in the fact that the undamaged consignments and much more metadata on the shipment is also analyzed. This data is already available in logistics companies and does not cause any additional costs in procurement. The automated analysis based on this and the associated possibilities for optimization are highly relevant for logistics companies. This is due to the fact that the reduction of the damage quota brings a multitude of benefits. The Opportunity Cost of leaving this data with enormous potential unused is high and avoidable. Figure 3 shows that in the conventional approach, a lot of data is not used and knowledge is not gained according to a defined and controllable procedure. Therefore, there is a risk that bad decisions will be made due to the insufficient evaluation of important information.

KNOWLEDGE TRANSFER BASED ON THE CASE STUDY

By using CRISP-DM, it was possible to create forecast models for the presented use case which can predict the occurrence of a damage during transport. Using the methods presented under Deployment, this data can be integrated into the regular business processes. To examine the applicability of the generated results for corporate practice within differing parameters, they are tested by means of a case study.

1. Plan: In the case study a research question has to be defined which is the starting point and aims at gaining knowledge through components like "how" and "why". Since the overall objective of this work is to increase knowledge in terms of practical applicability, the research question is: *„How do you evaluate the potential of the presented approach to damage prediction and why might there be challenges in its application in your company?*" By integrating the second component, the targeted question of possible challenges, optimization possibilities are deliberately explored.

2. Design: The case study is conducted according to the multiple case design. In order to increase the significance of the results, both the supply and the demand side in the freight forwarding market and different regions and modes of transport are to be examined. Theoretical replication increases the significance of the results and enables a more comprehensive picture. Due to the researcher's interest in the practical applicability of the generated results, literature-based research is not suitable to generate a gain of knowledge.

3. Preparation: Since, as described under 2, it is necessary to have direct interviews with representatives from business practice, measures to ensure the quality of the results are to be adopted. This is due to the fact that a consultation in conversation is comparatively open-ended (Przyborski & Wohlrab-Sahr, 2022). In order to obtain answers that were sufficiently representative of the entity under study, three representatives of each of the companies were interviewed in each of the interviews. The three information providers in the companies fulfilled different roles and represented different areas of responsibility.

4. Data Collection: As outlined in 1, in order to increase the transfer of knowledge, various perspectives on the market of the freight forwarding and transport business are to be recorded and evaluated in the study. Figure 5 shows which target com-ponents are to be analyzed within the scope of the study. It is assumed that limiting factors are to be regarded as additive and thus a company which is active in domestic and in road freight can name the limiting factors for these two areas. Thus, it is not necessary to find individual companies for each subject of analysis. Furthermore, it should be noted that the carriers are not the focus of the analysis, as they are already present as a variable in the modeling and thus the selection of the carrier is a modifiable component. The data acquisition was carried out via an open discussion in which the research question was integrated with an internationally active logistics service provider and a national mid-sized production company. The general conditions mentioned under step 2 (Design) were fulfilled.

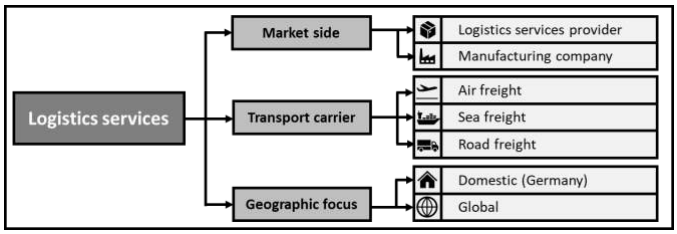

Figure 5: Case study focus

5. Analysis: The information generated from the interviews was evaluated and analyzed through a reconciliation and discussion among the research team ex post to the interviews. This evaluation of the interviewees' responses to the research questions was conducted in a way that the limiting factors mentioned were collected. This collection of information was then adjusted for company-specific criteria that in themselves do not represent an inherent limitation to the applicability of the fundamental approach. An example to be mentioned here is the use of Tableau instead of Power BI in the company. A substitution of Power BI in the described process would seem to be possible, therefore this argument was neutralized. Through this process, the most critical factors could be extracted from the interviews, these are:

- Procuring data in the areas of international air and sea freight is a substantial challenge due to the large number of parties involved and the lack of framework legislation for protocolling at interfaces.
- The approach only allows an evaluation on existing internal company data. Thus, the best possible selection of parameters can only be found out by trial and error. A cross-company platform is not available.
- The primary criticism is that the evaluation cannot be carried out ante and only past-based variables are integrated in the model. In particular, there is a need for information in companies in the connection of past-based data and descriptors from which future developments in supply

chains can be derived. Identifying emerging developments and risks and evaluating them in order to create an information basis for a countermeasure is seen as a performance-critical component.

The fundamental potential assessment of the interviewees was recorded separately by the research team and combined in a discourse process in order to prevent individual biases. A presentation of the intersection takes place in the following section.

6. Summary: Finally, based on the conducted case study research, the reference back to the opening research question is now to be made. Due to the bilateral nature of the research question, the knowledge gained is separated in relation to the two knowledge-forming components and these are presented individually:

- The fundamental potential of the approach is rated as high by representatives from the corporate practice. The primary driver for this positive assessment from the perspective of mid-sized, domestically operating companies is the potential for customer satisfaction and the positive impact on internal processes such as returns management and customer service. These aspects apply across all company sizes. In addition, above a certain company size, there is a positive impact on the bottom line due to a more cause-related cost breakdown to risk drivers. This enables a better expression of planning and control functions.
- Between the realization of the substantial potential mentioned, however, are the challenges in the implementation of the approach mentioned in the previous section. It should be noted that the closer the data is to the original use case (domesticated road freight, retrospective analysis), the smaller the impact of the limiting factors. Substantial gains can be made, however, if it is possible to mitigate the challenges mentioned above. This enables companies to realize considerable competitive advantages and to react faster to market movements.

CONCLUSION

The aim of this research was to showcase an initial approach for data mining in logistics predicting delivery damage probabilities and by that means going beyond the current big data analytics focus area within supply chain management and also to test the generated results with a case study. The results of the research show that the outlined approach of data mining with CRISP-DM can be used to proactively analyze existing data to predict probabilities for delivery damages depending on different factors. It can further be automated, deployed and used as a regular business process within enterprises to generate insights and enable improved evidence-based decisions upon controlling questions for instance. The presented approach was carried out with a test data set for the German road-freight market and could be used there relatively easily. Thus, the result of CRISP-DM is very positive. Based on the case study it is evident for other transfer cases (e. g. air and ocean freight, international freight), that there are some challenges to be overcome first. If this can be done, there is significant potential to be leveraged and several benefits can be reaped. One possibility seen by the authors is the integration of further data into the model which have a high degree of recency and are available internationally and freely. To make this possible in a standardized and cost-efficient way, data from news platforms, for example, could be captured, categorized by sentiment analysis, and then aggregated and finally integrated into the model. This makes it possible to react to developments before they affect the supply chain itself and thus to substantially increase the added value of the presented approach by integrating another integral component.

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Smart/Digital Logistics and Supply Chain Management

Digital supply chain transformation for dynamic green innovation – a conceptual framework

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INTRODUCTION

The emergence and diffusion of advanced digital technologies (DTs) — artificial intelligence, big data analytics, cloud computing, Internet of Things (IoT), advanced robotics and additive manufacturing, among others — is radically altering the nature of business production and supply chain management, increasingly blurring the boundaries between physical and digital systems. The adoption of these technologies can foster sustainable green development and innovation under the right conditions (UNIDO, 2020).

Existing research on DTs for green innovation reveals two directions of innovation, namely greening process and greening product. For green process innovation, production-side changes are emphasised to enhance supply chain operational efficiency enabled by lean and agility strategies (Tsai-Chi, 2018; Adams et al., 2016). For green product innovation, it relates to innovation to enhance effectiveness of green product design and business models for value added green consumer demand and markets (Melander, 2017; Hasan et al., 2019). With the application of DTs on the greening process and product, it is claimed that competitive advantages of business eco-efficiency and effectiveness can be realised. However, in reality, businesses with technological advancement in production efficiency can produce products with a lower labor cost that further stimulate demand. This could result businesses in investing in existing markets and boosting capacity and led to overconsumption issues (UNIDO, 2019; Ghobakhloo et al., 2021). Meanwhile, companies also struggle to exploit green value from product green innovation. The market for green products is seldom viewed as lucrative at the initial stage, especially in developing countries where environment technologies and policies are not well built and awareness for green consumption is also not developed. How companies can balance the supply side of eco-efficiency, while stimulating green demand for added value; and balance the demand side of eco-effectiveness while exploiting supply capacity fully. These questions require thinking from integrated demand and supply chain management for business green competitive advantages.

Green supply chain management (GSCM) emphasises the integration of environmental management objectives into supply chain operation objectives, covering areas of green purchasing, green production and operation, green logistics and reverse operations, customer cooperation with green concern, and close-loop management (Feng et al., 2022). Existing research discusses the technical application and the green effect of DTs in these aspects. However, most of these studies address the impact of green digital applications on operational execution and network planning within the respective functional silos. There is a lack of research on the green effect of digital structure on supply chain strategy. In reality, introduction of DT is not an issue of a single department. Instead, i involves an integrated collaboration of many different functional departments within the business (Sanders et al., 2019). Each business' setting of technological infrastructure is different with separate legacy system platforms. The demands of external stakeholder linkage are also different. Therefore, it is difficult for companies to gain a green value advantage by investing in a single application of technology. As such, digital transformation is facing many obstacles. How business can leverage an integrated supply chain digital transformation in the areas of supply chain system structure, digital operation platforms and infrastructure that aligns with its internal and external supply chain environment is the key for a valuable green transformation.

This research adopts a three-stage desk-top study involving a thorough literature review, content analysis and thematic coding on digital supply chain management for green innovation. Based on the findings, we develop a conceptual framework underpinned by the strategic fit of alignment theory stressing the digitalisation of the supply chain structural configuration for realising dynamic green competitive advantages, with a balance between cost-efficiency and green effectiveness at the process and the product levels.

LITERATURE REVIEW

Digital technologies leveraging green process and product innovation

Greening process innovation with leveraged lean and agility

Many studies discuss the adoption of DT in the manufacturing processes to improve *process visualisation*, thereby minimising environmental risk, pollution and waste output and other negative green impacts. Visualisation technologies including adoption of Internet of things and big data analytics that can monitor sources of pollution and detect errors in real time. IoT connect machines with embedded sensors and miniaturised computers building a network of *interconnected* smart objectives. Big data analytics enhance the data volume and velocity enabling speedy data processing analytics (Sanders et al., 2019). All these leverages a real time data analysis on the operating environment. Through the real-time monitoring of material flow and operating equipment, the flexible digital adjustment of parameters can accurately be achieved. Many discuss the impact of lean and risk control by application of DTs in traditional energy-intensive, large-scale industrial production industries, such as the steel industry (UNIDO, 2019). Lifting molten metal is one of the most dangerous tasks in the steel industry, and traditional processes rely on the experience of labour working, and a small mistake can cause irreparable damage. By introducing a smart crane that carries molten metal, the risk for workers is greatly reduced. Others discuss the impact of integration of RFID and controllers in optimising the utilisation rate of fixed assets and production processes, improving the accuracy and efficiency of large-scale lean operation. **Table 1** summarises the key eco-innovation approach leveraged by DTs for business realising various competitive advantages.

Some studies also discuss adoption of DT on disrupting traditional processes and transforming energy-intensive production models to more energy-efficient production models bringing a more positive green impact, improving efficiency of material input and resource utility. For example, three dimensional (3D) or additive manufacturing technology significantly reduces material consumption and improves energy efficiency compared to conventional machines. 3D printing technology can produce complex metal parts with excellent mechanical properties without the need for expensive tools, subverting the traditional subtractive manufacturing process to obtain parts components by removing leftovers, breaking through the limitations of manufacturability design and greatly reducing the amount of waste generated in the process. By changing traditional factory settings, supply chain structures, and reducing long-distance transportation, 3D printing enables customer-centric, decentralised, customised factories that focus on local needs. Others discuss capability of *adaptability and agility* of machine learning, artificial intelligence and big data technologies on production and other integrated processes including logistics, servicing and maintenance. This helps to build an integrated intelligent system powered by real-time data analysis that adapts quickly to changes in demand and production conditions, enabling automated and predictive maintenance. These applications also help manufacturers identify and automatically mobilise reusable resources in the system, increasing system level capacity utilisation (Andreoni and Anzolin 2019). Data from electronic devices, networks and internet-connected equipment can provide companies with insights about how they use their resources and how they could improve the design of their supply chain for circular economy (Rizos et al. 2018).

Despite the positive impact of DTs for businesses leveraging eco-efficiency, some also pointed out that solely pursuing eco-efficient innovation through green processes can lead to rebound effects. With the improvement of production efficiency, businesses can be incentivized to produce more products with lowing cost, thus, leading to rising consumption of waste from end consumers. Some highlight that if the introduction of technology only reduces internal operating costs, such as using robots to replace manual labour, rather than improving the comprehensive operation capacity of enterprises, it may bring a series of rebound effects, resulting in waste of resources and over-consumption on low-end products.

Green product innovation with customised design and servitization

Green product innovation emphasises use of DTs to improve the quality of use life, while minimising the emission of pollutants and waste (including carbon emissions and toxic substances) throughout the life cycle of products, and the use of resource input, bringing a significant positive impact on the environment. Many studies identify it as a higher level of technological innovation built from process

innovation, generating higher business value through developing better and more environmentally cost-effective products. DTs can significantly increase precision and accuracy along the entire production process, resulting in improved environmental performance and energy efficiency of manufactured goods, ultimately contributing to a reduction of carbon emissions associated with the product's functionalities (Ghobakhloo et al., 2021). For instance, the application of ADP technologies to solar panel production increased the quality and performance of its produced solar modules. It improves the solar panels' energy efficiency through optimising the use of resources, which in turn increases the competitiveness of solar power as a *reliable and cost-effective* source of energy. At the same time, through process innovation, businesses can further integrate durable, reusable and recycled elements to new product design, enabling internal circular economy. By introducing DTs, data from electronic, networked, and internet-connected devices across product lifecycle, can provide companies with insights into how to leverage total resources and improve product design and supply chain planning (Hasan et al., 2019, Malacina and Teplov, 2022). As a result, by controlling and reducing the flow of resources, especially raw materials and energy within the system, the possible degree of close-loop (green materials and recyclability) can be achieved, and the competitiveness of green products as *durable and cost-effective* products is improved.

Furthermore, new technologies can also enhance product-service characteristics and functionalities leveraging higher markup services and markets. Embedding new technologies into products can optimise their functionality, improve product quality standards, develop a wide range of *varieties*, thereby generating higher added value and entering a higher market niche (Bocken et al., 2014). UNIDO (2020) mention that smart production systems enable the direct involvement of customers in production, in facilitating *cost-effective customization* and in the *personalization* of products. Businesses can create as many products and services as possible with as few resources and environmental pollution as possible. The integration of DTs transforms physical products into integrated products and service packages, where manufacturers can control and improve the overall performance of products, including their energy consumption throughout their life cycle. As a result, leveraging the digital nature of physical products not only improves overall resource utilisation, but also brings new value to the business. However, others also question if green product innovation can truly bring eco-effectiveness advantages (Adams et al., 2016, Zeschky et al., 2014). The market for green products is seldom viewed as lucrative at the initial stage, especially in developing countries where environment technologies and policies are not well built and awareness for green consumption is also not developed.

Table 1: Role of digital technologies for business green innovations

Eco-innovation	Associated strategies	Attributes of digital technologies	Competitive advantage of eco-innovation	References
Green process innovation *Production-oriented*	• Emission and cost reduction and lean • Resource efficiency and agile	• Process visualisation • Real-time monitoring and analysis • Flexible adaptation	• Emission and waste reduction • Waste of resource reduction • Resource efficiency improvement	(Hahn, 2020, Adams et al., 2016, De et al., 2017, Hojnik and Ruzzier, 2016, Vrchota et al., 2020, Ghobakhloo et al., 2021, Wong et al., 2020)
Green product innovation *Customer-oriented*	• Green recycled materials and parts with improved quality • Customised service and product with green business model	• Product lifecycle resource flow visualisation • Real-time monitoring and analysis of product usage • Flexible match of products with	• Improve product performance and cost effectiveness • Improve product life cycle resource effectiveness • Increase the added value of products	(De et al., 2017, Ghobakhloo et al., 2021, Melander, 2017, Kazancoglu et al., 2021, Silva et al., 2019, Silvestre and Tirca, 2019, Yu et al., 2022)

		users		

Impact of digital technologies in green supply chain management

GSCM emphasises the integration of environmental management objectives into supply chain operation objectives, covering areas of green purchasing, green production and operation, green logistics and reverse operations, customer cooperation with green concern, and close-loop management (Feng et al., 2022, De et al., 2017). Many studies discuss the advanced DT adoption in GSCM highlighting the green impact of digital applications under related functional areas (see **Table 2**).

In the field of green purchasing, the impact of DTs is mostly discussed in two aspects: 1) increasing visibility and traceability on green supplier selection, and 2) increasing decentralisation for data security. Adoption of big data analytics, intelligent industrial algorithms and other applications, can facilitate business screen and evaluate suppliers, continuously track green materials and parts production information. At the same time, through the use of blockchain technology and smart contracts and other applications, information security and tamper-proofing are guaranteed, thereby further ensuring procurement security and environmental compliance.

In the field of green production, the impact of intelligent manufacturing is discussed in aspects of: 1) improving visualisation and real-time monitoring of process planning and operation on pollution control; and 2) dynamic process adjustment on pollution prevention, remanufacturing and waste optimization. For instance, the use of Internet of Things, cloud computing and other applications can capture the dynamic data of the production floor to achieve process visualisation and real-time monitoring of operations, reducing output of pollution and waste. By using artificial intelligence algorithms to replace manual and supply chain simulation platforms and big data platforms, real-time problem perception and identification with early pollution warning, and dynamic process adjustment on pollution prevention and remanufacturing can be leveraged. In addition, through the introduction of intelligent robots and 3D printing technology, manufacturers can have a positive impact on labour cost reduction, saving production consumables, and reducing errors and defects.

In the field of green logistics and reserve operations, some studies explore the efficiency and safety of smart devices in transportation network planning and capacity execution. By deploying IoT sensors in the transportation system, logistics enterprises can read and optimise the optimal vehicle loading, route planning and dynamic real-time data, which can realise the process visualisation of the logistics end. Both freight and personal vehicles are equipped with a variety of sensors (cameras, GPS, etc.) that analyse real-time data about vehicle performance and the surrounding environment to avoid or minimise potentially hazardous situations, improving the safety and efficiency of transportation networks. Other studies further discuss the advantages of autonomous vehicles and drones in saving logistics operating costs and labour. Finally, data from mobile devices and vehicle GPS sensors is able to connect location and trajectory data to individuals using transportation networks, resulting in a sharing economy.

In the area of green customer demand and close loop management, the impact of intelligent manufacturing is discussed in aspects of: 1) improving seamless connectivity and adaptability between consumers and businesses for a variety of products and services 2) generating in-depth information about consumer behaviour for personalised services. Consumers can now seamlessly switch between channels when evaluating, purchasing, returning, or seeking assistance with products and services under the adoption of the Internet of Things, mobile applications, and the collection of client-side data. The granular data enables real-time personalization. Based on customer attributes, which include demographics, location, or browsing history, products, offers and prices can be personalised and "pushed" to customers in real time. Through big data and intelligent algorithms, accurate analysis and

characterization of consumer behaviour provide the possibility for enterprises to understand customer preferences and improve services to guide green consumption.

In summary, we find that existing GSCM studies discuss application of DTs mostly in supply chain operations, and network planning for the purpose of internal risk and resource control, and improving integrated resource efficiency. The adoption of DTs improves operational and process visibility, traceability, connectivity and flexible adaptability. However, topics related to the strategic level of GSCM and supply chain eco-design are less researched.

Table 2: Applications of digital technologies in GSCM

GSCM related areas	Application of DT	Leveraged green impact	Research focus	References
Green purchasing	Adoption of big data analytics and artificial intelligence for green supplier selection and evaluation, green materials and prats real time tracking	• Optimise green supplier selection • Control risk of sourcing	• Operational execution • Strategic decision making	(Alavi et al., 2021, AlNuaimi et al., 2021, Foroozesh and Tavakkoli-Moghaddam, 2017, Galbraith and Podhorska, 2021, Gnoni et al., 2011, Gordon, 2021, Handfield et al., 2020)
	Adoption of blockchain technology for data security and decentralisation of transmission	• Reduce sourcing risk	• Operational	(Chung et al., 2019, Handfield et al., 2019, Stekelorum et al., 2021)
Green production	Adoption of the Internet of Things, big data analysis, and artificial intelligence for monitoring pollution and adjust process in real time	• Reduce waste of resources • Improve resource efficiency	• Operational execution • Process planning	(Bag et al., 2020a, Bag et al., 2020b, Bag et al., 2021b, Bodendorf et al., 2021, Felstead, 2019, Hayhoe et al., 2019, Howard et al., 2021, Narwane et al., 2021, Penumuru et al., 2020, Stehel et al., 2021, Guha and Kumar 2018)
	Replace traditional manufacturing with additive manufacturing 3D printing	• Reduce resource input	• Operational execution	(Tsai-Chi and Smith, 2018, Koh et al., 2019; Baumers and Holweg 2019, He and Bai 2021)
	Adoption collaborative robots for repetitive labour working	• Reduce cost of labour input • Improve safety of work environment	• Operational execution	(Pei et al. 2017; Baumers and Holweg 2019; He and Bai 2021)
Green logistics and reverse operations	Adoption of the Internet of Things, big data analysis, and artificial intelligence to optimise route	• Improve logistics efficiency • Reduce emission	• Operational execution • Network planning	(Aloui et al., 2021, Damoah et al., 2021, Demirova, 2019, Govindan et al., 2019b, Gutierrez-Franco et al., 2021, Hill and Bose, 2017, Hopkins and Hawking, 2018, Klumpp, 2018, Su and Fan, 2020, Tsang et al., 2018)
	Adoption of collaborative robots and autonomous driving technology, in line with human resources	• Improve flexibility through human and machine interaction	• Operational execution	(Boru et al., 2019, Gruzauskas et al., 2018, Sah et al., 2021, Sodero et al., 2019)
	Adopt big data analysis, and blockchain platform to trace and analyse data of product end life	• Improve system resource efficiency	• Operational execution • Network planning	(Akinade and Oyedele, 2019, Bag et al., 2021a, Bag and Pretorius, Di Vaio et al., 2020, Frota and Dutordoir, 2020, Govindan et al., 2019a, Gumte et al., 2021, Yu et al., 2022, Rajput and Singh, 2019)

Customer cooperation with green concern	Adoption of the Internet of Things and big data analysis, for consumer behavior analysis, based on data from different platforms	• Improve green consumption value	• Operational execution • Network planning • Strategic decision making	(Deng and Liu, 2021, Dubey et al., 2021, Nguyen et al., 2020, Shafiq et al., 2020; Gu and Tayi 2017; Guanka et al., 2020; Singh et al., 2018)
Close-loop operation	Adoption of big data, artificial intelligence algorithms to generate qualitative analysis and connect consumption and production data during the life cycle of green products	• Improve system resource efficiency • Improve circular economy	• Operational execution • Network planning	(Dubey et al., 2018, Gupta et al., 2019) (Cheng et al., Chidepatil et al., 2020, Dora et al., Hirata et al., 2021, Kazancoglu et al., 2021, Yu et al., 2022, Keivanpour and Kadi, 2018, Saurabh and Dey, 2021)

METHODOLOGY

This study adopted the desk-top research methodology involving a three-stage "funneling" process to systematically review the relevant literature on sustainable/green innovation, GSCM and DTs.

The first stage involved the identification of relevant databases and articles. A broad search of academic databases highlighted 64 relevant business-related academic databases were conducted. Keywords including "green or sustainable supply chain", "green or sustainable or eco innovation", "green process innovation", "green product innovation", and "digital technology* or digital supply chain or digital manufacturing" were used in identification of the seminal, journal and recent research works in the field. Other sources of information used in the literature review include online articles, industrial white papers, and latest news announcements. Over 500 papers were identified initially, then reduced to a short list of 50 most relevant ones.

The second stage of the desktop research used content analysis to identify and categorise the key issues and themes discussed in these articles. This involved systematically coding and categorising the data to identify key themes and patterns. The content analysis was conducted using a coding manual that was developed to ensure consistency and reliability in the coding process. The coding manual was reviewed and refined several times during the coding process to ensure that the themes and categories were comprehensive and accurately reflected the data.

The third stage of the desktop research adopted thematic coding analysis to identify the qualitative links across the key themes for generating new conceptual elements and in-depth analysis. This involved grouping the data into broader themes and subthemes to identify the most significant patterns and relationships between the data. The themes were developed based on the data, and were reviewed and refined as necessary to ensure that they accurately reflected the information contained in the data. The thematic coding was conducted using NVivo that allowed for the systematic organisation and analysis of the data.

FINDINGS

Integrated eco-innovation leveraged by business supply chain digital transformation

Based on literature review and content analysis, we find that although attempts have been made to realise eco-innovation advantages through embedding digitalisation on process and product level, few have discussed the integration of two approaches to balance the business objective of eco-efficiency and effectiveness. The issues of balancing the supply side of eco-efficiency while stimulating green demand for added value, and the demand side of eco-effectiveness while exploiting supply capacity fully require the thinking from integrated demand and supply chain management for business green competitive advantages.

Also, few have discussed the strategic level of digitalization. Strategic digitalization enables businesses to better integrate green goals into supply chain strategies with the help of an integrated information system platform (visibility, traceability and dynamic adaptability). This enables the business to take the environmental goal as a competitive priority in line with the economic goal of traditional supply chain competitive advantages including efficiency and effectiveness for value creation (Jeble et al., 2018, Kache and Seuring, 2017). Digital supply chain transformation focuses not only on technological

breakthroughs in single-point operation, but also on the design and configuration of an overall information system and architectures. It facilitates the coordination of supply and demand relationship of external partners, and internal cross-departmental cooperation, and breaks the data barriers of each functional silo (Ittmann, 2015, Tsai-Chi and Smith, 2018, Nayal et al., Raut et al., 2021).

According to above, we propose a conceptual framework of digital supply chain transformation for dynamic green innovation underpinned by the strategic fit of alignment theory (Port, 2011; Fisher, 1997; Chorn, 1991). We propose that the goodness of digital green supply chain competitive transformation requires the alignment of green demand and green supply management to form dynamic choices of green supply chain strategies, with aligned green competitive advantages of its product market.

The framework comprises two dimensions of green innovation: the SCM dimension and the corporate dimension (see **Figure 1**). The SCM dimension depicts leveraging right digital SCM elements for integrated green innovation strategies. Underpinned by literature review, green innovation strategies are identified as emission reduction and lean, resource efficiency and agile, green product design with recycled resources, and green customised service and business model design. Three aspects of digital supply chain transformation can be identified as digitalization of external strategic supply chain relationships, digitalization of cross functional supply chain planning and digitalization of the internal supply chain operations. We aim to examine how businesses will select the right digital elements from three aspects for a specific combination of green innovation strategies across green products and green processes.

The corporate dimension relates to leveraging a specific combination of green supply chain strategies for integrated green competitive advantages. Underpinned by literature review, business green competitive advantages include a series of objectives of eco-efficiency and eco-effectiveness. We aim to observe how different combinations of strategies will be adopted for business to achieve green competitive advantages.

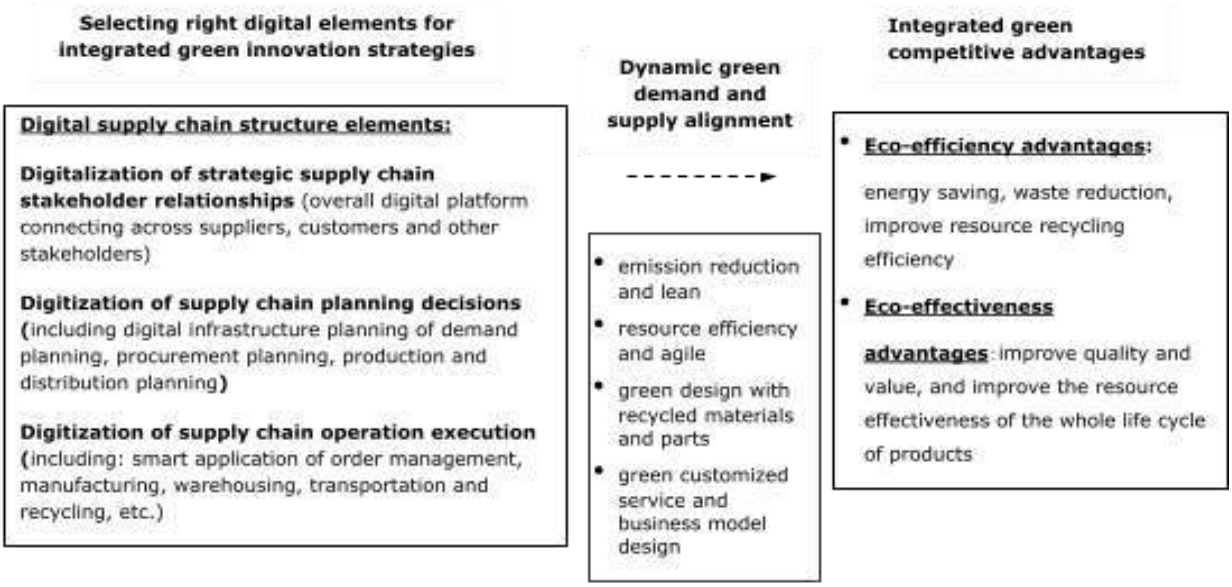

Figure 1: A conceptual framework of digital supply chain transformation for dynamic green innovations

CONCLUSION

This study systematically reviews the literature of DT application in business green innovation and GSCM. Through a three-stage funneling review process, we identify the limitation of existing green innovation strategies and digital adoption of technologies on GSCM strategies. We propose a conceptual framework for integrated supply chain digital transformation in the areas of overall supply chain system structure,

digital operation platforms and infrastructures for dynamic green innovations. Underpinned by the strategic fit of alignment theory, the proposed framework highlights that businesses' DT adoption for competitive green objectives should be aligned with their internal and external supply chain environment, considering both green demand and supply characteristics. Businesses can leverage appropriate combinations of green innovation strategies based on their demand and supply conditions for dynamic adaptation facilitated by an integrated digital platform, and finally achieving a series of hybrid green competitive advantages. This study contributes to knowledge of green innovation strategies and GSCM research by proposing hybrid solutions of innovation. It also adds to industrial practices by identifying paths for digital supply chain transformation and green innovations for supply chain practitioners.

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Building Resilience for Supply Chains

Geo-Political Turbulence: how Governance and Power are Exercised in Global Supply Chains

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INTRODUCTION AND PURPOSE OF THIS PAPER

Turbulence and disruptions in global supply chains are on the rise due to political instability, natural disasters and unpredictable events, and other catastrophic events and crises. Many governments across the globe, and their economic business models, are being challenged by what Nafday (2009) describes as "black swan events" – happenings that have enormous consequences. The recent and ongoing COVID-19 pandemic, the Russia and Ukraine conflict, and geo-political issues have certainly exposed the fragility of global supply chain systems. Even high-value manufacturing (HMV) supply chains that are inherently 'projects' configured, such as railway projects, have been significantly disrupted due to compounded vulnerabilities of pre-existing constraints, policy decision-making uncertainties, and metagovernance legitimacy. That said there are still several high value manufacturing (HMV) railway projects that are currently being planned and/or delivered across the globe. These projects range from High-Speed 2 (HS2) in the UK at an estimated value of $136bn; Chuo Shinkansen at $84bn, which will introduce new magnetic levitation technology into Japan's high-speed rail network; and, the California high-speed rail project at $80bn (Railway Technology, 2022).

In the context of the UK global rolling stock manufacturing industry (GRSMI), existing literature highlights an interesting conundrum, which is that the UK 'railways' policy and drive for privatisation is so ingrained in political ideology that it hinders the ability to manage and thus adequately understand industry governance and power relations, especially when faced with various existential challenges from countries/regions that have a different political ideology, such as China (El-Said, Cox and Evans, 2022). Cory (2021) and Cox (2022) argue this point further by stating that the drive for [all things] privatisation dramatically adds to margin erosion, which is widely regarded as a detriment to innovation. However, in times of economic uncertainty and instability, Cory (2021) acknowledges that a drive towards privatisation is a need and an economic instrument.

In addition, in 2017 the GRSMI hierarchy suddenly changed when the Chinese government announced the merger of their state-run HVM railway companies by combining the China Northern Locomotive and Rolling Stock Corporation (CNR) with the China South Locomotive and Rolling Stock Corporation (CSR) to create the China Rail Rolling Stock Corporation (CRRC). The outcome of this merger was the birth of a powerful monopolistic state-controlled/funded HVM rolling stock company that overshadows global competition with an annual turnover in the region of $32bn. The nearest rival to this is Alstom SA (post-acquisition of Bombardier Transportation in 2021), which has a turnover of $9bn (Bizvibe, 2021).

By adopting a state-of-the-art (SotA) literature review (Mitchel & O'Blenis, 2018), limited studies were found that directly question legal frameworks surrounding governance, current relations around power, policy decision-making arrangements, and what El-Said, Cox and Evans, (2022) deem as the concept of metagovernace legitimacy, all within the UK GRSMI. This is in relation to whether existing governance and policies are robust enough to mitigate the challenges posed by the economic shift in GRSMI market dynamics driven by China's powerful mercantilist and protectionist business models. Also, the SotA literature review does not examine potential policy change strategies that could improve the effectiveness of state-funded versus privatised business models in the UK, especially post-Brexit.

LITERATURE REVIEW

The rail policy decision-making model adopted by the UK government for industrial privatisation involves the country being served by major rail routes such as the East and West Coast Mainlines that link London to Edinburgh via the Midlands and East Anglia (Cox, 2022). These routes are operated by a franchise model whereby train operating companies (TOCS) such as Avanti, East Midlands Trains Southwestern Trains and Thameslink operate HVM products (i.e., trains) across their region (National Rail Enquiries, 2021) independently from government control. However, train operating companies do not own or

purchase HVM/rail assets from the government, each HVM railways project builds the HVM products for rolling stock leasing companies (ROSCOs), which means that decision-making around network policy (i.e., input legitimacy and output legitimacy) is influenced by stakeholder value (El-Said, Cox and Evans, 2022). Atkinson (2021) suggests that it is now time to investigate whether the UK's governance and approach to power relations needs a rethink in the face of overwhelming challenges from foreign influence, more specifically the China railways sector.

Policy decision-making outcomes and metagovernace legitimacy adopted by the Chinese government have proven successful in developing countries and economies with less developed railway technology and innovation; for example, Latin America (Buchanan, 2021). Cory (2021, p.4) states that "*one of the key goals of the Chinese government is to break into the developing world rolling stock market*". That said CRRC has already achieved some success in the HVM rolling stock market with projects being awarded for the Los Angeles subway upgrade and Metro cars in Israel (Railway Technology.com 2021). CRRC was also awarded the Porto light rail vehicle contract in Portugal in 2020. However, this project has since been beset with long delays and project failures. In addition to this, HVM rolling stock projects in Latin America have motivated CRRC to build regional headquarters in Mexico with projects secured in nearby Chile, to which Buchanan (2021) alludes to as an added incentive to the competition landscape for contract bidding.

In response to China's railways strategy and network policy decision-making, the US house of representatives looked to ban CRRC from tendering for HVM railways projects on US public transportation systems in 2019 by passing an annual defence bill that would block the use of federal funds to be used with Chinese companies stating that it was an issue of national security (Xinyuan, 2019). In comparison to China, the UK's railways strategy, and network policy decision-making, which shifted in 1993 to unilateral privatisation, has courted much controversy with perceived decision-making outcomes and metagovernance legitimacy far from what was originally intended. Metagovernace legitimacy is a clear indication of power relations around how policy decisions are made, reached, and delivered, and how there is a clear need for better understanding and transparency (El-Said, Cox and Evans, 2022). The concept of metagovernance has attracted quite some attention in the supply chain management literature and is widely seen as a solution to governance failures (Jessop, 2011).

Focusing on the theoretical domains of supply chain management governance, the SotA literature review sought to investigate two key themes. The first key theme was based on empirical and practitioner studies that describe and critically analyse how policy-making decisions around metagovernance legitimacy are made in the GRSMI. This also includes identifying any insights into how effective those policy-making decisions have been in delivering metagovernace legitimacy within the Chinese and UK HVM rolling stock markets. The second key theme was based on studies that seek to compare the input legitimacy and output legitimacy of China's network policy-making decisions versus Western counterparts (more specifically, the UK). The analysis focuses on the change in network policy strategy instigated by the Chinese government in 2017 with the creation of CRRC (Li and Wang, 2021). A further objective was to review the literature investigating the effect such network policies have had and are having on policy decision-making (Li, Zhiwei and Honghai, 2016), in the GRSMI. However, this paper sought to establish further insights and observations across the literature regarding global rolling stock power relations, leverage (specifically the UK) concerning China and their network policy change, and the effect that this has caused.

To identify the scope and depth of the literature, the first step was to decide on a date range in which to look for papers. To remain consistent with other studies it was decided to extend the search date range from 2002 to 2022. That date range sufficiently covers China's initial entry into high-speed rail development through a vertically integrated policy of inclusion (and exclusion) driven by imports and foreign investment in technology and innovation through to the sudden policy change seen in 2017 culminating in their accelerated position of strength and power in the present-day GRSMI and market.

Following on from the date range, key search words and phrases were selected such as rolling stock manufacturing, CRRC policy, rolling stock governance, power relations and leverage in the rolling stock industry. To enhance the search, a further sub-set of keywords and phrases were used such as UK rail network policy, railway governance, metagovernance and legitimacy, power in China and belt and road initiative. Sentences that contained any of these criteria were captured and consolidated to measure frequency and establish key themes. Additionally, the journal repositories examined were limited to science direct and emerald. The articles included in this paper focused on studies that examined network policy, power relations and governance of the GRSMI.

Existing studies in both academic and practitioner literature seek to demonstrate the effect of China's network policy and governance change towards the GRSMI by focusing on how the Chinese government have actively pursued strategies, to which Cory, (2021) describes as 'Mercantilism' and 'Protectionism' by accelerating technological advancements of their high-speed rail network over the space of 20 years at the expense of key manufacturers in the industry. However, the literature does not pose the question of whether the rapid transfer of knowledge and capability from the UK is due to poorly administered metagovernance legitimacy and how decisions are made, reached, and delivered based on free trade markets that are intended to mitigate margin erosion and to create profit through increased competition.

It is also claimed that China's rapid advancements were achieved through the acquisition of foreign technologies and intellectual property (Atkinson, 2021). Indeed, according to Atkinson (2021, p.11), *"China used mercantilist policies to rapidly and unfairly close the gap, taking advantage of the development of its massive high-speed rail network to unfairly seize foreign technology and know-how to support its local champion, CRRC, and other rail firms"*. The literature seemingly fails to acknowledge whether China's rise to economic power in the GRSMI has been helped by different governance arrangements and diluted decision-making through the high inclusion of UK private companies being allowed to shape network policy through input legitimacy and thus reaching decisions without challenge from the UK government. Again, it can be argued that privatisation sought to reduce the transparency of decision-making in the UK GRSMI (El-Said, Cox and Evans, 2022).

The literature describes how China's mercantilist and protectionist actions were the catalyst for the attempted merger of Alstom and Siemens rail in a bid to create a company capable of challenging CRRC globally and warding off the threat of foreign colonialism and monopolisation of domestic supply chains (Cory, 2021). Pang (2020) describes how France and Germany actively sought to change longstanding power relations and governance by altering competitive policies through the European courts to create a 'Railbus' scenario effectively protecting the European-based rolling stock sub-tier supply chain from losing all its power to the Chinese competitors. Pang (2020) also alludes to the fact that the merger was ultimately rejected by the EU high commission because the strategy directly contravened the basic principles that the European merger policy model is based on and would diminish the power and/or influence of other EU member states. It is further argued by Pang (2020) that creating another European champion could disadvantage less technologically advanced EU nations in favour of the traditional manufacturing powerhouses which could stifle innovation and increase margin erosion. A potential weakness of any merger policy is that it could make member states with a high level of decision-making influences inflexible and thus unable to react quickly to adversaries with fewer stakeholders. This is another issue that the literature fails to address, choosing instead to accuse China of underhand tactics rather than focusing on the limitations of Western policy such as privatisation in the UK and proposing lessons learnt.

Perhaps timelier and more congruent to the current issues faced by the GRSMI and challenges posed by CRRC are studies that seek to critically analyse the UK's privatisation policy change in 1993 with the introduction of the Railways Act 1993. Jupe (2010) challenges whether the UK's policy (in line with the EU free market) of de-nationalising and disaggregating the railways industry from a state-owned public-sector model to a fragmented private-owned model through rail franchising has worked. Jupe (2010, p.347) argues that in fact the opposite of what the then 1993 UK Conservative government envisaged has happened by stating *"Rail privatization led to a large increase in both costs and subsidy, and there*

have been substantial performance and regulatory problems with rail franchises. Franchising is, in the language of the House of Commons Transport Select Committee, a policy muddle. A way forward would be to bring franchises into the public sector as they expire or as train operators run into difficulties". The change in policy was intended to promote efficiency, reduce public subsidy, and drive-up competition to improve product/service quality, cost, and delivery for end users of the UK railway network – the metagovernace legitimacy and optimistic forecasts of the then UK government proved to be very different.

Some studies seek to examine the wider strategy around metagovernance by comparing China's vertically integrated supply chain in relation to growing the high-speed rail market. The literature seeks to analyse how the policy might be connected to the wider belt and road initiative that seeks to link China to the European Union by road and rail. Yan (2019, p.1) describes how *"China's high-speed rail endeavours could thus become an important leverage for China in becoming a new land power, starting with improving connectivity and gaining road rights"*. However, the literature does not examine this strategy in relation to the UK's persistence with the privatisation model. Recentralising the domestic high speed rail industry is part of China's economic statecraft to influence and control competition, which in their view is the best way to manoeuvre champion companies into the geopolitical global arena (Yan, 2019). By contrast, the UK's strategy, and policy around metagovernance seem to have allowed the domestic rolling stock manufacturing industry (DRSMI) to fall into significant foreign ownership. This means any policy-making decisions that the UK government make, and thus the DRSMI companies don't like, simply result in threats to offshore, and thus take manufacturing facility out of the country.

RESEARCH METHODS AND DESIGN

To deepen the understanding of governance and power relations currently adopted in the GRSMI, this paper adopts a relations matrix (RM) (Figure 1 below) to further understand the term "metagovernance", which is an organisation's, or an institution's, ability to drive policy making-decisions to safeguard and thus deliver legitimate network policy outcomes (Gjaltema, Biesbroek and Termeer, 2020). This paper aims to critically evaluate the current strategy and policy adopted by the UK government for managing large-scale rolling stock manufacturing projects and compare this with China's current adopted strategy and policy. Input legitimacy and output legitimacy are typologies of metagovernance illustrated as trade-offs in policy-making outcomes underpinned by the decisions made, reached, and delivered. The RM illustrates varying differences in governance, power relations and policy decision-making outcomes between two widely contrasting [geo]political ideologies.

	Stakeholder Involvement in Policy Creation		
Ownership	Key: China UK	Input legitimacy (Influence) with regard to network policy and meta-governance?	Output legitimacy (Measure) with regard to network policy and meta-governance?
	Private-Owned Company Centred Governance	Input Legitimacy – China = Low (Exclusion) Input Legitimacy – UK = High (Inclusion)	Output Legitimacy – China = Low (Exclusion) Output Legitimacy – UK = Medium (Inclusion)
	Government-Owned Centred Governance	Input Legitimacy – China = High (Inclusion) Input Legitimacy – UK = Low (Exclusion)	Output Legitimacy – China = High (Inclusion) Output Legitimacy – UK = Medium / Low (Exclusion)

Figure 1: The Relations Matrix for China and UK

The RM highlights the level of influence that stakeholders impose over policy creation and measures the output of such influence. In other words, how much power do stakeholders exercise over

changing/creating network policy in the GRSMI, and possibly in the DRSMI? The RM also compares the level of governance-centred involvement in the decision-making process by private-owned companies in comparison to government-owned bodies.

The RM evaluates how inclusion and exclusion in network policy-making decisions can lead to different metagovernance outcomes or outputs. Inclusion and exclusion relate to the number of entities given privileged access to the policy-making process and thus metagovernance outcomes to create stability over a period. In addition, the RM implies that there are various trade-offs (through inclusion and exclusion) when applying different governance-centred arrangements, which may well raise questions about how to achieve high levels of positive input and output legitimacy at the same time.

FINDINGS AND VALUES

Through different governance arrangements, the effectiveness of China's metagovernance outcomes and various trade-offs towards their respective GRSMI has been highlighted, in comparison to the UK's GRSMI over the past 20 years. The outcome of China's network policy has involved driving a high level of input legitimacy towards government-owned domestic decision-making, which has strategically been geared towards reducing the number of private-owned companies that are active in the Chinese GRSMI, and their DRSMI.

China has subsequently been able to facilitate a high level of government inclusion in policy decision-making because of the significantly reduced number of stakeholders. The result has been a vastly improved output legitimacy, justifying China's need to be state-owned. Subsequently, China's government now have complete power/influence over their rolling stock manufacturing industry whereas private companies have virtually none.

Due to China's network policy-making decision to merge the two biggest rolling stock manufacturers, and thus subsequent metagovernance outcomes, the Chinese government now has complete control over the largest rolling stock manufacturing company in the world (according to revenue) including ownership of all IPR, technology and brand image of CRRC. The drastic change in China's network policy is now posing an existential threat to their Western Counterparts. The RM argues how power relations and governance is exercised and thus highlights how government-owned manufacturing economic business models have allowed this to happen in record time, and without political repercussions or interference from weak trade bloc policies such as the EU's public procurement model, which would have prevented the move.

By comparison, an analysis of the UK's network policy decision-making, and metagovernance outcomes since the privatisation of the UK rail industry in 1993, most certainly paints a completely different picture when viewed through the RM. Input legitimacy of the UK government on key policy decisions in the rolling stock manufacturing industry has decreased to a low level from an inclusion perspective with most policy decisions being made by private companies. The increase in key stakeholders introduced by privatisation has made decision-making very onerous and time consuming. The consequence of too many decision-makers has resulted in the output legitimacy for private companies being considered medium at best with key rolling stock projects often being delayed and running over budget. This failure is further exacerbated by the effects that privatisation has had on excluding the government and reducing its power and influence on policy in the rolling stock manufacturing industry. Since privatisation began, the technology and manufacturing capability that the UK once had have systematically diminished and transferred to foreign companies including Chinese manufacturers.

Overall, the power relations and governance matrix are not intended to show how policy-making decisions and outcomes, and meta-governance outcomes, are better than the other, but it does highlight several trade-offs and issues that can occur when it comes to the long-term effect that they can have on an industry. By reducing the number of stakeholders and decision-makers, China has the ability to drive and influence policymaking to safeguard and thus deliver legitimate policy outcomes and meta-governance outcomes. Therefore, like the US house of representatives, the RM suggest that the UK

government needs to limit the power and opportunities of private-owned capitalist companies that are heavily influenced or owned by governments. This is especially those that have been accused of mercantilist and protectionist strategies by restricting their ability to tender for HVM rolling stock projects. These issues need to be acted upon to improve innovation and reduce margin erosion through collaboration with other countries that have more transparent decision-making policies and to prevent government-owned companies from harvesting all technology and IPR.

RESEARCH LIMITATIONS AND PRACTICAL IMPLICATIONS

Practically speaking, and by contrast to what this study now defines as the Chinese meta-governance policy demonstrated since 2017, the RM suggests that the UK's meta-governance policy of staunch capitalist privatisation and supply chain inclusivity since 1993 has been a failure. Privatising the UK railway industry has not delivered on the meta-governance outcome legitimacy that strategy and policymaking were meant to, much to the detriment of the end-user i.e., British rail commuters through high ticket prices and poor quality of service. However, a serious consequence of the low outcome legitimacy of the privatisation strategy is that the UK is now not currently able to radically change its policy around metagovernance to redress the balance and thus reduce vulnerabilities versus powerful economic adversaries. This is driven further by the consequential effect of China's high levels of output legitimacy from government-driven network policy decision-makers. Low-cost country sourcing is in effect part of the calculated mercantilism that comes with the ability to drastically undercut all competitors in the global market – the great walls of protectionism.

As some of the empirical literature suggests, China's meta-governance policy strategy towards the rolling stock manufacturing industry forms part of a bigger picture and is connected to the belt and road initiative that seeks to link China with Europe by road or rail (Yan, 2019). The evidence suggests that the Chinese government not only want to use that link to increase trade with Europe the UK and the West, but they want to control it, so their strategy towards inclusive government policy decisions has been part of a much wider long-term goal to gain a significant economic advantage.

Therefore, areas for future research should seek to investigate and propose how the RM can be used to understand the effect stakeholders have in terms of power and influence over policy change/creation. It is also interesting to assume different perspectives from a governmental state-funded company versus a privatised business model and company viewpoint. This will allow us to highlight potential risks and mitigate the consequences of poor decision-making and margin erosion for all stakeholders. This can be achieved by demonstrating how network policy decisions can have adverse consequences on the UK economy and not just the average rail customer.

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Transport & Distribution

A Review of Business Analytics Used in Port Operations

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ABSTRACT

Purpose: Ports play an essential role in enhancing the flow of goods through the global supply chains, where many players interact in different operations with a high degree of complexity. The management of supply chain operations requires analytical methods to support with the decision-making process (Mar-Ortiz et al., 2018). Using analytics within ports it is not a new phenomenon, where various tools, analysis, technologies have been used in ports for a number of years to improve operations. Business Analytics (BA) approaches are used in port operations in various forms to create values from data available to them. The operations in ports present many complexities as well as ports depend on the operations of many other players who all seek to create value from data and maintain their competitive position in the current market. The scope of this paper is to bring further understanding on how business analytics are considered and implemented in ports.

Design/ methodology/ approach: The approach adopted in this research is to take a critical view on understanding the opportunities offered by BA and more specifically analytics adopted in ports by reviewing current literature and reporting on key findings. A systematic review of the literature has been conducted following published literature from 2015 to 2020. This review considered as main search engines Google Scholar, Scopus and Emerald. This study followed a six research steps approach identified in (Denyer & Tranfield, 2009) and has resulted in a review of 93 publications.

Findings: Based on findings from the literature the discussion brings a critical view on the opportunities offered by implementing business analytics in ports. The motive considered for adopting analytics in ports together with the benefits offered by their implementation is also captured within this debate. The limitations observed from adopting analytical tools in ports is also discussed here. Analytical tools and techniques have been adopted in ports and this is captured by various examples from the literature, however we have observed that there are limited set of tools that have been applied for similar problems.

Value: This approach has allowed the authors to start constructing a library of BA tools and techniques that are mapped on a set of characteristics based on the problem they solve, ease of use, and practical applicability (Tipi, 2021), while offering practitioners and researchers the opportunity to search for the most appropriate tool and analytical approach used in ports' operations. Several insights are provided that contribute to the current research agenda in the field of business analytics adopted in ports.

Research implications: This work brings further understanding to theory on how BA are perceived, what reason guided their adoption, and which are the key limitations users will need to be aware when adopting analytics in ports. Several practical benefits can be observed from adopting analytics in ports, where this work puts this understanding forward to be further considered by managers in ports.

INTRODUCTION

Maritime transportation plays a key role in a global trade, where increasing the port's efficiency is essential in maintaining a competitive advantage as well as improve operational flow for organisations using this mode of transport. Ports play a key role in making the link between different global locations, where at the same time perform several operational tasks (Sarabia-Jacome et al. 2020). Emerging technologies such as Internet of Things (IoT), Cloud Computing, Big Data analytics tools, Artificial Intelligence, Machine Learning, Simulations and others, form part of the set of tools ports are looking at

evaluating and adopting with the scope to improve their operations, communications between different stakeholders and the decision-making processes that governs the port.

Due to the complexity of operations in ports, a number of issues can be noted such as delay in loading and unloading, documentation flow, long waiting time for berthing, safety issues, and many others for which the involvement of analytics and analytical techniques could bring significant benefits into providing a solution in overcoming some of these problems.

Using analytics within ports it is not a new phenomenon, where various tools, analysis, technologies are used in ports to improve operations. Therefore, the authors are looking to bring forward the current definition governing business analytics in ports, and with this setting the following aim for this paper. This paper aims to capture the use of BA tools and techniques applied in ports and the motive considered for their adoption together with the benefits offered by their implementation. This approach allows the authors to construct a library of business analytics tools and techniques that are mapped on a set of characteristics based on the problem they solve, ease of use, and practical applicability, while offering practitioners and researchers the opportunity to search for the most appropriate tool and analytical approach used in ports' operations.

To follow this aim, the paper is organised as follows. The next section looks at defining the terminology used for BA. To fully understand the development, applicability and use of BA in ports, a systematic review of the literature has been employed that allowed us to thoroughly understand this phenomenon. An explanation of the methodology used to carry out the systematic review of the literature has been summarised in section three. In section 4, different BA approaches, and applications used in ports, their benefits and limitations are being indicated through a discussion of the results captured from the literature considered within this research. Problems solved in ports with the use of analytical techniques have been identified and categorized in section 5. The last section focuses on providing a conclusion and indicating future research agenda.

BUSINESS ANALYTICS

The impact of successfully applying BA in ports can be significant in terms of improving ports' performance as well as improving the overall performance of the network a particular port is being part of. This paper starts with the view that BA uses technology to support and enhance the decision-making process, however it is not a technology (Tipi, 2021). It is claimed that BA is a combination of tools, approaches and procedures that have the ability to collect the most relevant details and information, store these in the most secured way, visualising these in the most appropriate way, providing predictions on what may happen, and has the ability to indicate solutions for what can be done based on what might happen in the future (Tipi, 2021). Therefore, BA has the potential to change the way in which decisions are being made within a port as well as it could put the port above its competitors and creates efficiencies in the supply chain this port is part of. There are however a number of challenges when ports are looking to develop and use analytical capabilities. These directly relate to challenges in acquiring the right data to support the analysis, to have the most appropriate information systems that would support a range of different transactions, to ensure sufficient analytical skills are in place to operate with particular intelligent tools and interpret the results and having full awareness of the value analytical tools can bring in relation with systems' investment.

Previous studies focused on illustrating future advanced information and communication technologies (ICTs) applied in the maritime transport such as Internet of Things (IoT), big data, cloud computing, autonomous ships/vessels (including unmanned ships/vessels) (Bălan, 2018. However, we can note a large selection of tools and techniques applied, we lack the opportunity to understand which tools, techniques to be used based on the problem they solve. A tool that has the ability to help managers in their decision-making process based on the problem they are looking to solve has the potential to bring a significant contribution to the field of BA in ports.

SYSTEMATIC LITERATURE REVIEW METHODOLOGY

This research applies a Systematic Literature Review (SLR) approach. It includes the review of business analytics applied in port operations and follows the approach based on the six research steps identified in (Denyer & Tranfield, 2009):

Formulation of the research questions
To explore this study, the following research questions have been formulated:

RQ1: *Which analytical tools and techniques have been implemented and applied in port operations?* This research question has been set to allow authors to explore a range of tools and techniques captured under the understanding of "*business analytics*" used within ports with the scope to improve their operations. However, analytical tools have been used for a number of years, we are capturing those that have been seen by other researchers under the umbrella of business analytics.

This is then followed with a second research question set as RQ2: *What type of problems are solved by adopting BA in ports?* The intention in this case is to provide an understanding of problems that are being approached by particular analytical tools.

Port managers will benefit from a guide on how tools and techniques can be selected, and which tools are the best in what situation. Therefore, we consider that a database of tools applied in ports that capture benefits and limitations will be a particularly useful tool for port managers to have access to when looking to adopt analytics in ports.

Keywords, search criteria and identification of studies
The review of the literature has been conducted on material published from 2015 to 2020 on three main search engines: Google Scholar, Scopus and Emerald. The original search has started with keywords such as 'port operations' and 'prescriptive analytics', however, this resulted in very restrictive set of publications. Therefore, we have extended the keyword search to 'port and analytics' and 'seaport and analytics'. It can be argued here that this again may have been a restrictive search, as analytics may not be a term used in the main key search when this is applied as a tool or a technique in the abstract of a research paper. Therefore, we have extended the search to be applied not only to the 'title, abstract and keywords search', but to be applied to the entire paper. A list of 523 articles was collected, examined, and evaluated through four phases. At the end of these four phases a final list of 93 articles has resulted that fit with the purpose of this research – analytical tools and techniques adopted in ports.

ANALYSIS AND SYNTHESIS

The analysis stage has started with the set of 93 articles saved in a spreadsheet forming the analysis tool used for this investigation. This comprised elements such as paper title, authors names and year of publication, journal names, abstract and authors keywords. On top of these, the analysis tool captured area of ports/functional area; purpose of analysis as captured within the analysis; the identified limitations of the analytical model put forward by authors, and the port related problem these tools were used for.

BA tools
Many analytical tools have been used by researchers in the context of port operations for example, internet of things, big data, blockchain technology, analytics network processing, artificial neural network. Some of these tools with their characteristics are captured below:

Analytics Network Process (ANP) - Abdoulkarim et al., (2019) have used this tool to identify the optimum selection of locating dry ports. They have used this tool to identify the relative weights required for calculations. Following this approach, a classification of locations of where to build dry port was possible which has brought practical benefits to local government in deciding where would be best to construct a dry port. From this research we learn that this is of benefit to policy makers involved in urban planning and port planning in landlocked countries like Niger, where the case study of the investigation was from. Still, this is to note that this particular approach, can also be extended to other cases and other locations. Augustin et al., (2019) have also used ANP for dry ports formulation problem that considers a multi-criteria evaluation technique through a pairwise comparison and a super-matrix formation. ANP was also

used by Ha and Yang, (2017) in combination with AHP technique, to determine the relative importance of port performance indicators. Therefore, we see that ANP can be used not only as a facility location technique, but also to evaluate the relative importance of port performances.

One other analytical technique considered is the *blockchain* technology. This was used by Acciaro et al., (2020) who argue that this technology has the capacity of capturing a very large number of characteristics about a product or a commodity that is important for a port and they have used blockchain to understand the physical and financial traceability of the goods. The authors recognised that with the development of physical internet and various methods of monitoring data will bring significant benefits to ports and they need to ready for these developments. Lambourdiere and Corbin, (2020) argue that maritime supply chain is still very reliant on the use of physical paperwork for various transactions required in port. Shippers and consignee are faced with a large number of interactions with various stakeholders in the chain only to be in a position to move a physical good from one location to another, and this is done still with means of physical document, via phone, email of fax. The authors have looked at proposing a theory of digitisation in the form of using blockchain to improve efficiency and effectiveness of maritime supply chain performance.

Machine learning - Chan et al., (2019), presents this method as a Support Vector Regression method; where they have identified that machine learning approach is a better choice than other time series forecasting models. Within this example, we learn that this method is used in ports for predicting container throughput. Ansorena and Ansorena (2020) have employed machine learning methodology based on a classification and regression tree (CART) model. For this model, it is considered that port managers can predict the number of vehicles, or passengers that will use the ferry terminal. The use of this model, when predictions are reliable, bring benefits to port managers as well as ferry operators. A larger number of predictions are to be considered in ports from predicting container throughput, to port utilisation, to vehicles required, to number of passengers and so on. Machine learning proves to be one of the analytical methods highlighted as particularly useful in ports.

Artificial neural network (ANN) and support vector machines (SVM) algorithms are other two algorithms that are used by Caliskan and Karaöz, (2019) to predict the movement of throughput in ports. This model is designed to help managers in developing a short-term logistics plan. *Analytical Hierarchy Process (AHP)* is another analytical tool used to identify the competitiveness of the transhipment port by Chen et al., (2017). AHP is used in combination with another technique such as fuzzy-AHP by Gao et al., (2018) and looks at evaluating port competitiveness.

Data Envelopment Analysis (DEA) is a method used in combination with other approaches. For example, principal component analysis-data envelopment analysis (PCA-DEA) has been used by Chen et al., (2016) to evaluate and analyse the relative efficiency of the iron ore logistics at ports in a particular area. Deepankar and Chowdhury, (2020) have used DEA technique to demonstrate that privatised terminals have not performed as well as intended and was used as a tool to inform the stakeholders decision.

Big data analytics addresses issues of large volumes of data, data that has different dimensions, characteristics, and data that brings a dynamic element into the discussion has been used by Cheng, et al., (2016) however they have also added the point of swarm intelligence that is an optimisation technique inspired by nature. In their paper the authors have captured two swarm intelligence approaches: particle swarm optimization (PSO) and ant colony optimization (ACO). Kim et al. (2017) are also using big data in vessel tracking using real-time data in combination with historical data and this has proved particularly useful for vessel delays detection. Min et al. (2017) is proposing the use of big data for security detection problems as well for improving productivity. This is by updating big data related to cargo movement, port infrastructure, and ocean-going vessel traffic. Big data analytics is used in many instances in ports, still the issues surrounding data accuracy, data storage, transparency, visualisation remain key aspects for decisionmakers, port managers.

Optimisation with the use of *integer programming* (Dong et al., 2021) model is established to optimise ship loading, transportation timeliness, and operation efficiency. Yan et al. (2020) is using optimisation models (speed optimisation) in combination with other models.

PROBLEMS SOLVED IN PORTS WITH THE USE OF ANALYTICAL TECHNIQUES

Based on the systematic review in the field of port analytics, a classification was made based on problem solved and this was classified into five main categories as follows. This was in support to the research question RQ2.

Performance management
The authors have identified that performance management has a number of sub-categories in practice, the first of which is *operational performance improvement*. Performance improvement in operational terms is particularly interesting when it is able to influence the competitive position by being able to deliver superior value and/or offer prices through lower costs. A number of different tools have been identified in this direction and they are (Ha and Yang, 2017, Chen et al. 2015, Deepankar and Chowdhury., 2020, Kayikci, 2021): port performance measurement (PPM) and comparison research present multiple-criteria decision making (MCDM); risk in logistics; decision tree analytics; sustainable performance; FAHP techniques, big data, Web crawling, text mining, semantic network analysis. *Port competitiveness* - is the degree to which a port competes with another port or ports. For example, Chen et al. (2016) used the PCA-DEA model, and Gao et al. (2018) used Fuzzy-AHP and ELECTRE III. *Green performance* - as today's competitiveness is highly rising in the global maritime sector, it is paralleled with an increased concern about the sustainability of operations and the environment. The literature reviewed indicates that the purpose of most of the research is to identify major green port performance indicators and to evaluate ports' overall green performance. Authors used many tools, such as: optimisation, and AI, storage space allocation, MIP formulation, analytic hierarchy process (AHP), and grey relational analysis (GRA) (Chen and Park, 2017).

Optimisation, Planning and Forecasting
The optimisation is divided into two subcategories, the first is *digitalisation and technologies*. Digitalisation and the adoption of IT systems are currently one of the most important directions in maritime transport and, in particular, port development. The digital revolution affects all aspects of port operations. This has been clarified by previous studies through the use of a set of tools such as: optimisation, data analytics, data analytics and AI, BDA, and swarm intelligence (SI) in BDA (Cheng and Zhang, 2016).

The second category is *optimisation management*, which means the management of transport infrastructure which is an important issue for the added value it offers. Transport terminals, corridors, ports require management efficiency to deliver a high performance which sometimes is perceivable to the national gross product. Previous studies dealt with many tools, including the integer programming (IP) model established to optimise ship loading, transportation timeliness, and operation efficiency; followed by a simplified IP; followed by differential evolution algorithm (Dong et al., 2021), data mining, and complex network theory (Van Nguyen, 2020), berth allocation and quay crane assignment problems (BA-QCA); proactive planning approach by taking into consideration the vessel arrival delay into the optimisation of BA-QCA problems; modified genetic algorithm and a new quay crane assignment heuristic to maximize the schedule reliability of BA-QCA (Wang and Guo, 2018).

Risk management was divided into two subcategories, the first is *maritime, and worker's security* which is responsible for protecting crew members on board ships as well as dock and port personnel. Maritime security guards work on cruise ships and private boats as well. Maritime security guards are typically deployed in locations where there is a significant danger of piracy or vessel robbery. This has been clarified by previous studies through the use of a set of tools such as visualisation data analytics (Betty, 2017), technology RFID (Bauk et al., 2018), security; technology: X-ray based cargo inspection; use of big data (Min et al., 2017).

Container management
Container management refers to a collection of procedures for managing and maintaining containerisation software. Container management solutions automate the construction, deployment, decommissioning, and scaling of application or system containers (Kuźmicz and Pesch, 2017, Chen et al., 2017). For container type issues, several tools have been identified such as DSS; mathematical

programming problem as well as prediction model on dwell time (Maldonado et al., 2019) and online stacking system.

Also, the study of *container forecasting* as forecasting container throughput, and seaport service rate prediction system. Previous studies have used several tools, including time series forecasting methods, including machine learning-based methods (Chan et al., 2019). *Container monitoring* such tracing and monitoring every single movement and storage of incoming cargo containers, and early detection of vessel delays using different tools such as integrated terminal operating system (ITOS) (Min et al, 2019), and real-time vessel tracking information; data-driven method (Kim et al., 2017).

Sustainability

The concept of sustainability for ports is the integration of environmentally friendly methods of port activities, operations, and management. Any development causes the minimum possible impacts, contributing to improving measures and controls for the quality of the air, water, noise, and waste. Previous studies have dealt with sustainability in ports in various forms, which include *regulations and policies* as selecting the best location for the construction of a dry port, estimating and computing the monetary value of connected vehicle data, investigating the role of process coordination dynamics and information exchanges in maritime logistics, seaports positioning and assessing the exposure and sensitivity of seaports to climate and extreme weather impacts using various tools as Analytic Network Process (ANP) Model (Abdoulkarim et al., 2019), Process Mining (PM), Social Network Analysis (SNA) and Text Mining (Aloini et al., 2020).

CONCLUSION

Only a few of business analytic tools have been detailed in this paper based on the reviewed carried out. Only some of the identified problems have been captured in the discussion based on what these tools can be used. There are a number of other areas that business analytics have been noted to bring benefits and they will continue to bring further benefits. The papers selected in this review looked primarily to bring the understanding of BA and their application, however a number of other publications that do consider BA tools, however not presented under the umbrella of business analytics have not been captured by this search. The authors see this as a limitation in this case, and this is seen to further add to our understanding of defining business analytics. These publications have been published within a range of different journals, where there is no one single group of journals that captures the majority of journal papers reviewed here. This again is a point to be highlighted in support of defining the use of business analytics in ports.

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Customer-Supplier Relations

Does organisational culture matter for supply chain collaboration and competitive advantage: the case of garment firms in Vietnam

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INTRODUCTION

Supply chain collaboration has received considerable research attention in the last few years. The effect of supply chain collaboration on firm performance has been investigated as a mainstream of supply chain management; however, this effect has not been yet fully understood. For example, while Zhang and Huo (2013); Ralston *et al.* (2015) find a positive relationship between supply chain collaboration and firm performance, other studies (Flynn *et al.*, 2010; Wiengarten *et al.*, 2019) conclude mixed findings, while Zhao *et al.* (2015) report a non-linear relationship. Moreover, only a few studies have investigated the relationship between supply chain collaboration and firms' competitive advantage (Liao *et al.*, 2017), especially in terms of cost and differentiation.

Additionally, many investigations in the literature have studied the impact of organisational culture or supply chain collaboration on firm performance individually. However, those previous studies are inconsistent in their findings about the relationship between organisational culture and supply chain collaboration. For example, using the Competing Value Framework (CVF) proposed by Quinn and Rohrbaugh (1983), it was found that both development and group culture are positively related to all three dimensions of supply chain collaboration in some studies (Cao *et al.*, 2015; Porter, 2019), while group culture appears to have no impact on supply chain collaboration practices in the others (Braunscheidel *et al.*, 2010; Taha *et al.*, 2022). Hence, the effect of these types of organisational culture on supply chain collaboration and competitive advantage requires further investigation.

Supply chain collaboration in the garment industry is pivotal due to the fragmented nature of supply chain in this industry. There are many intermediaries exist between fibre producers and consumers. On this note, some studies have been conducted to address the issues of supply chain collaboration in the garment industry (Ramanathan and Gunasekaran, 2014; Vanathi and Swamynathan, 2014; Bari and Park-Poaps, 2020). For example, while Vanathi and Swamynathan (2014) and Bari and Park-Poaps (2020) study the impact of supply chain collaboration on competitive advantage in India and Bangladesh, Phan *et al.* (2020) examine the influence of supply chain practices, relevant to supply chain collaboration, on supply chain performance in Vietnam. However, these studies do not analyse internal collaboration and antecedents of supply chain collaboration.

Vietnam is ranked number fourth of the five leading clothing exporters in the world. This sector contributes about 20% to the national GDP and employs more than three million people (Phan *et al.*, 2020). Meanwhile, Vietnamese garment companies rely densely on overseas suppliers in terms of input materials and market. Besides, the issues of lack or weak links among supply chain partners are commonly mentioned in the public media (Trang, 2020). Therefore, collaboration with suppliers and customers is proposed as a solution for the success of the garment industry in Vietnam (Pham *et al.*, 2020).

This research, in response to previous studies' mixed results and call for future research (Liao *et al.*, 2017; Wiengarten *et al.*, 2019) especially regarding the potential relationship between organisational culture and supply chain collaboration and its effects on fims' competitive advantage, therefore investigates these relationships in the context of the garment industry in Vietnam.
The remainder of the paper is structured as follows. First, the theoretical background and research framework are presented in Section 2. Afterwards, the research methodology is given in Section 3. Then, results and discussion are provided in Section 4, and the paper is concluded with academic and practical implications, limitations, and future research in Section 5.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The Relational View (RV) provides the theoretical support for the role of a network of relationships between companies to achieve competitive advantage (Dyer and Singh, 1998). It suggests that relationship-specific assets, partner-specific knowledge-sharing routines, partner-resource complementarity, and efficient governance structures positively contribute to firm performance. In the context of this research, the RV provides the theoretical support for the role of supply chain collaboration as a way to exploit complementary capabilities to achieve competitive advantages.

Meanwhile, the Institutional Theory (INT) posits that a firm's business decisions are affected by the economic, social, and political forces exerted by relevant institutions, such as states and local governments and influential organisations (Scott, 2001). Organisations operate in a social system whereby social rules influence organisational practices. This theory has been used to explain various external factors that force organisations to implement new approaches, policies, and procedures (Saeed *et al.*, 2018). Hence, the prospective impact of organisational culture on how a firm's collaboration is conducted can be underpinned by this theory.

Since organisational culture refers to the shared values and beliefs of a company, it is vital in guiding the member's behaviour, which further affects supply chain collaboration. This research employs the CVF to analyse organisational culture since the framework has been widely used and substantially validated in numerous studies (Cao *et al.*, 2015; Lee *et al.*, 2016; Porter, 2019; Hong *et al.*, 2020; Taha *et al.*, 2022). Accordingly, the framework includes four types of culture, namely, development, group, hierarchy, and rational culture. Previous research shows that hierarchy culture is negatively related to both internal and customer collaboration (Cao *et al.*, 2015) or financial performance (Fekete and Bocskei, 2011), while rational culture insignificantly impacts external collaboration (Cao *et al.*, 2015). Therefore, this study focuses on the two remaining types: development and group culture.

Previous studies have analysed supply chain collaboration by focusing on activities or dimensions. Based on activities, there are four main mechanisms of collaboration commonly considered in prior studies: information sharing, goal congruence, decision synchronisation, and incentive alignment (Liao *et al.*, 2017; Zhang and Cao, 2018). Since the internal relationship among functional departments within a company is essential, this paper analyses supply chain collaboration from the view of internal, supplier and customer collaboration.

Competitive advantage is "the extent to which an organisation is able to create a defensible position over its competitors" (Porter, 1985). In previous studies, competitive advantage includes six dimensions: price/cost, quality, delivery speed, product innovation, time to market, and process flexibility (Liao *et al.*, 2017; Teng *et al.*, 2022). They reflect either the cost leadership or differentiation aspect of competitive advantage (Porter, 1985; Demeter *et al.*, 2016) and thus the latter are adopted in this research.

Companies that have a group culture emphasize the importance of values, traditions, teamwork, loyalty, shared objectives, dedication, and involvement of members within the organization, according to Cameron and Quinn (2011). Besides, a development culture has an external outlook and puts emphasis on creativity, growth, dynamism, and innovation. The positive relationship between these types of organisational culture and supply chain collaboration has been investigated previously (Cao *et al.*, 2015; Lee *et al.*, 2016). Moreover, the prospective impact of various organisational factors, including organisational culture, on how a firm's internal and external collaboration is conducted can be underpinned by the INT. Thus, the following hypothesis is proposed:

H1. Organisational culture (group and development types) positively relates to supply chain collaboration in the garment firms in Vietnam.

The positive impact of supply chain collaboration on firm performance has been examined in the literature (Zhang and Huo, 2013; Ralston *et al.*, 2015; Porter, 2019). Internal collaboration involves understanding mutual responsibility and joint planning to solve operational problems among functional

departments to achieve common goals (Flynn *et al.*, 2010; Zhao *et al.*, 2013). Besides, external collaboration is often reflected by sharing operational information and joint planning **on product assortment, and collaborative problem-solving with suppliers and customers (Zhao *et al.*, 2013). Thus, s**upply chain collaboration can contribute to cost and differentiation by providing more accurate and updated demand and supply information, production plans and future directions (Schoenherr and Swink, 2012) and reducing uncertainties (Wong *et al.*, 2011). Moreover, the role of internal collaboration and external collaboration as means to exploit complementary capabilities to achieve a competitive advantage is supported by the RV. Therefore, the following hypotheses are posited:

H2a. Supply chain collaboration positively relates to cost competitive advantage in the garment firms in Vietnam.
H2b. Supply chain collaboration positively relates to differentiation competitive advantage in the garment firms in Vietnam.

From the theories and literature review, a conceptual framework to evaluate the role of organisational culture in supply chain collaboration and competitive advantage was proposed in Figure 2.

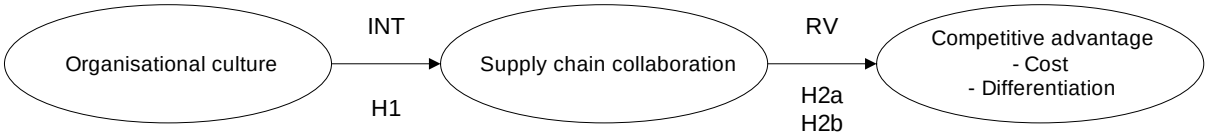

Figure 2 Conceptual framework

RESEARCH METHODOLOGY

The study population is manufacturing companies which are the main players in the garment industry in Vietnam. The unit of analysis is the organisation. The sampling frame was consolidated from the Vietnamese Textile and Garment Directory 2020 and several official websites i.e. the Vietnamese Ministry of Industry and Trade, and the Vietnamese Ministry of Planning and Investment.

The measurement constructs were developed based on the literature. As shown in Table 1, the construct of organisational culture is measured by development culture and group culture, while supply chain collaboration by internal and external collaboration. Meanwhile, competitive advantage is attributed by cost and differentiation aspects. The details of the measurement items are presented in the Appendix.

Table 1 Constructs and dimensions

Constructs	Dimensions	Sources
Organisational culture (OC)	Development culture Group culture	Cameron and Quinn (2011); Cao *et al.* (2015)
Supply chain collaboration (SCC)	Internal collaboration External collaboration	Flynn *et al.* (2010); Zhao *et al.* (2013); Thai and Jie (2018)
Competitive advantage (CA)	Cost (Cost_CA) Differentiation (Diff_CA)	Wiengarten *et al.* (2014); Demeter *et al.* (2016)

Based on the conceptual framework, a survey questionnaire detailing each construct was designed. The questionnaire consisted of five-point Likert scale questions, with 1 representing "Strongly disagree" and 5 denoting "Strongly agree". In addition, the survey instrument followed the forward-backward translation process, which in this study involved the translation from English to Vietnamese, then back-

translating into English and comparing to the original English version to ensure the equivalency of both versions (Chen *et al.*, 2010). The questionnaire was subsequently examined through pre-test and pilot-test procedures (Hair *et al.*, 2018). The questionnaire was reviewed for readability and ambiguity, and the feedback was used to modify the questionnaire. The final Vietnamese version of the questionnaire was delivered to participants via the Qualtrics application.

Of the 1,919 emails with the link to the Qualtrics application that were sent to the potential participants, 451 were undeliverable. Hence, the potential sample size was reduced to 1,468. From this pool, 709 responses were recorded. After examining issues related to missing data, outliers, non-normality, multicollinearity, and common method bias, 192 usable responses remain for further analysis. Thus, the overall response rate was 10%.

With regards to the sample characteristics, the larger proportion of participants was middle and senior managers at 56%, followed by officer/staff at 35%. In terms of working experience, the number of participants who had worked in the companies for more than five years was 50%. Most of the participants came from the departments related to supply chain management; for example, production with 24%, sales and marketing with 15%, and research and development with 12%.

Factor analysis was conducted to ensure the internal consistency of the attribute combination by using SPSS 28.0. Confirmatory Factor Analysis (CFA) was then used to examine the convergent and discriminant validity of the constructs. The relationships between organisational culture, supply chain collaboration, and competitive advantage were tested using the structural equation modelling in AMOS 28.0.

RESULTS AND DISCUSSION

As shown in Table 2, Cronbach's alpha values of all constructs were higher than the threshold of 0.7. The average variance extracted (AVE) score of each construct is above 0.50, and the construct reliability (CR) score is above 0.7. The results provide sufficient evidence that the convergent validity of the full measurement model was established (Hair *et al.*, 2018). Besides, all items were strongly loaded (>0.7) on their corresponding factor, and the square root of the AVE value for each reflective construct was larger than its correlation with all other constructs (see Table 3). These results indicate the discriminant validity of the construct.

Table 2 Construct reliability analysis

Constructs	Number of items	Cronbach's α	CR	AVE
Diff_CA	5	0.855	0.838	0.508
Cost_CA	2	0.744	0.780	0.649
OC	6	0.849	0.821	0.696
SCC	9	0.820	0.737	0.584

Table 3 Discriminant validity analysis

	Diff_CA	Cost_CA	OC	SCC
Diff_CA	**0.713**			

Cost_CA	0.356***	**0.806**		
OC	0.625***	0.173	**0.835**	
SCC	0.345**	0.150	0.612***	**0.764**

***p<.001, **p<.05

The KMO measure was 0.829, within the expected range of 0.5 to 1. Bartlett's Test of Sphericity was significant with the Chi-square = 2233.001, df = 300 and Sig <.001. Those results indicate that the sample size was adequate for factor analysis. There is a good model fit, with an acceptable level with Chi-square/df = 1.719; CFI = 0.920; SRMR = 0.062; RMSEA = 0.061, and PCLOSE = 0.048. The final causal model, in which the construct of organisational culture and supply chain collaboration are analysed at the second-order level (Phan *et al.*, 2020), is presented in Figure 2.

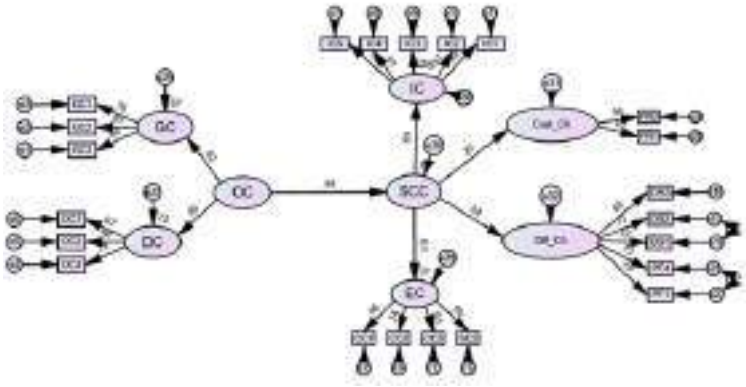

Figure 3 Final causal model

Table 4 Results of hypotheses testing

Hypothesis	Relationship			Estimate	S.E	C.R	p	Supported?
H1	SCC	←	OC	.591	.127	4.663	***	Yes
H2a	Cost_CA	←	SCC	.600	.219	2.733	**	Yes
H2b	Diff_CA	←	SCC	1.043	.240	4.339	***	Yes

***p<.001, **p<.05

Table 4 shows that organisational culture positively affects supply chain collaboration (i.e., Hypothesis H1 is supported). More specifically, development culture is positively associated with supply chain collaboration. This result implies that the dominant attributes of the development culture i.e. entrepreneurship, creativity, and adaptability would enhance supply chain collaboration. Indeed, firms with those cultural aspects nurtured within their organisations, which drive innovation, tend to implement more collaboration practices both internally and externally, since their innovation capability can be enhanced with higher level of supply chain collaboration (Liao, Hu and Shih, 2021). This result further supports previous studies (Braunscheidel *et al.*, 2010; Pinho *et al.*, 2014; Cao *et al.*, 2015; Porter, 2019). Secondly, the results indicate that group culture positively relates to supply chain collaboration. It is because the organisation associated with group culture emphasises cohesiveness, participation, and teamwork. This result is consistent with numerous previous studies (Cao *et al.*, 2015; Schilke and Cook, 2015; Lee *et al.*, 2016). However, this finding challenges the idea that group culture does not impact the firm's adoption of supply chain integration (Braunscheidel *et al.*, 2010; Taha *et al.*, 2022). This inconsistency is likely due to the national culture since it is noted that the effects of internal

and supplier integration on firm performance are stronger in Asian collectivist than in Western individualistic cultures (Chang *et al.*, 2016).

There was a significant positive relationship between supply chain collaboration and cost competitive advantage (i.e., Hypothesis H2a is supported). In this connection, manufacturing firms are likely to obtain adequate inputs by sharing the inventory level information and joint planning on inventory requirements. In addition, suppliers may inform manufacturers about the quality and quantity of the upcoming materials in advance. Therefore, production managers could allocate suitable labour to minimise unit manufacturing costs. Besides, since the number of workers is also stable, the production costs are reduced, resulting in a better product price. This finding is consistent with previous studies (Schoenherr and Swink, 2012; Wiengarten *et al.*, 2014).

Besides, the results reveal that supply chain collaboration positively impacts differentiation competitive advantage (i.e., Hypothesis H2b is supported). In the case of the imported-oriented supplier network in the garment industry, manufacturers face increasing uncertainties from upstream due to changes in transportation, duties, weather, and regulatory environment (Danese et al., 2013). Complex procedures associated with international logistics can also cause delays in getting input materials. Therefore, the collaboration between the manufacturer and its supply chain partners is required. Although it may be argued that supplier collaboration is not significantly related to delivery to customers (Wiengarten *et al.*, 2014), by updating the operational information timely with suppliers, the manufacturers can get the materials on time, which, in turn, leads to meeting customers' deadline (Boon-itt and Wong, 2011). On the other hand, the information about inventory level, labour, and product and process are likely to be shared with the customer representative. Moreover, getting feedback and support from customers on delivery is also helpful in enhancing competitive advantage, in agreement with that of previous studies (Danese *et al.*, 2013; Wiengarten *et al.*, 2014). On top of that, through sharing operational information to customers, firms can better respond to their customers' requirements, i.e., changes in delivery or production volumes (Wiengarten *et al.*, 2014).

CONCLUSION

This study aims to investigate the impact of organisational culture on supply chain collaboration and competitive advantage in the garment industry in Vietnam. The results show a significant correlation between organisational culture regarding group and development types and supply chain collaboration. In addition, supply chain collaboration enhances competitive advantage in terms of both the cost and differentiation. This study extends the application of the RV and INT theories in explaining the relationship among organisational culture, supply chain collaboration and competitive advantage. It is also one of the first empirical attempts to investigate this relationship in the Vietnam garment industry context. The findings imply that the owners and managers of garment companies should pay more attention to building group culture and development culture in order to enhance supply chain collaboration. Since supply chain collaboration encompasses both aspects of internal and external collaboration, firms should pay equal attention and allocate resources to establishing, nurturing and maintaining those collaborative relationships as they would positively enhance their competitive advantage. Despite these contributions, this research did not attempt to analyse differences in supply chain collaboration and competitive advantage taking into account firm characteristics such as processing types, ownership, and time in the market. This limitation could be addressed by future research, which can also examine these relationships in other industries.

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Appendix 1. Constructs and measurement items

Constructs	Measurement items	Sources
Organisational culture	**GC1. Your supervisors encourage employees to work as a team.** **GC2. Your supervisors encourage employees to exchange opinions and ideas.** **GC3. Your supervisors frequently hold group meetings for discussion among employees.** **DC1. Your firm pursues long-term programs for manufacturing capabilities in advance of needs.** **DC2. Your firm tries to anticipate the potential of new manufacturing practices and technologies.** **DC3. Your firm stays at the leading edge of new technology in the industry. *** **DC4. Your firm is constantly thinking of the next generation of manufacturing technologies.**	Cameron and Quinn (2011); Cao *et al.* (2015)
Supply chain collaboration	**Internal collaboration** **IC1. The functional departments in your firm regularly conduct joint operational meetings.** **IC2. The functional departments in your firm achieve common goals collectively.** **IC3. The functional departments in your firm understand the mutual responsibility.** **IC4. The functional departments in your firm mutually share operational information.** **IC5. The functional departments in your firm conduct joint planning to anticipate and resolve operational problems.** **External collaboration** **CC1. Your firm shares operational information (procurement, inventory, forecasting…) with major customers.** **CC2. Your firm shares the information with major customers through information technologies.** **CC3. Your firm and major customers jointly plan on product assortment.** **CC4. Sharing benefits and risks is a primary principle of your firm's relationships with major customers. *** **CC5. Your firm and major customers dedicate personnel to manage the collaboration processes. *** **SC1. Your firm shares operational information (procurement, inventory, forecasting…) with major suppliers. *** **SC2. Your firm shares operational information with major suppliers through information technologies.** **SC3. firm conducts joint planning with major suppliers to maintain a rapid-response ordering process. *** **SC4. Sharing benefits and risks is a primary principle of your firm's relationships with major suppliers. ***	Flynn *et al.* (2010); Zhao *et al.* (2013); Thai and Jie (2018)
Competitive advantage	*Cost* PR1. Your firm can provide prices as low or lower than that of your competitors. PR2. Your firm manufactures similar products at a lower cost than your competitors. *Differentiation* DS1. Your firm delivers customer order on time to be compared with your competitors. DS2. Your firm's delivery is more reliable than that of your competitors. DS3. Your firm's order fulfillment lead time is shorter than that of your competitors. QL1. Your firm provides high-performance products that meet customer needs to be compared with your competitors. * QL2. Your firm produces consistent quality products with low defects to be compared with your competitors. * PF1. Your firm has ability to respond to changes in delivery requirements to be compared with your competitors. PF2. Your firm has ability to customize products to be compared with your competitors. * PF3. Your firm has ability to produce a range of products to be compared	Wiengarten *et al.* (2014); Demeter *et al.* (2016)

	with your competitors. * PF4. Your firm has ability to rapidly change production volumes to be compared with your competitors.	

* Items that have been deleted due to the low loading

Framework for continued fit of delivery methods in the supply chain of a luxury food company

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INTRODUCTION

The luxury goods industry represents a key market segment, with the personal luxury goods market having shown accelerated growth of 22% to €353 billion in 2022 from 2021. The personal luxury market is projected to see further growth of at least 3-8% in 2023, even given a downturn in global economic conditions. By 2030, the market value is expected to climb to around €540-580 billion, a rise of at least 60% compared to 2022 (Bain, 2022). The luxury industry must adapt to a growing and more global market and new technologies while fulfilling customer needs and maintaining its essential features which has attracted their customers to begin with.

On the one hand, the luxury industry is traditionally represented by high-quality products that infuse customers with exclusivity perception, including customer service which traditionally was done face-to-face (Wiedmann et al., 2009). On the other hand, despite the predominant role of physical stores in regard to distribution channels, e-commerce is seeing rapid growth in this sector (Bain, 2021). However, several new technologies are shaping the field of delivery services and services in general, for instance through the use of omni-channels, forcing the luxury sector to develop agile responses to these developments (Abtan et al., 2016).

The approach luxury companies should have in relation to these new delivery trends and their application has not been well investigated. The food segment that is part of the luxury industry is even further under-researched within this field. However, this segment is showing a steep increase in popularity and revenue. By 2030 the global population is expected to adopt healthier food habits, to become more educated on food matter and to have an increased disposable income. Future trends in the food sector will be the increased importance of health concerns, sustainability, food origin and innovation (Lem et al., 2014). These principles are directly linked to the luxury sector and its main product features (Caniato et al., 2009). The scope for this research is limited to the Nordics (Denmark, Norway, Sweden and Finland) due to the adaptability to technology, trust level, Gross Domestic Product (GDP) per capita and growing luxury food industry (Andersen et al., 2007; The World Bank, 2022).

Through an explorative case study, this paper focuses on how luxury food companies in the Nordics can adapt to future trends in delivery methods while meeting customer expectations.

LITERATURE REVIEW

A structured literature review on the latest trends within delivery methods combined with a benchmark from leading luxury brands and their delivery suppliers, whenever relevant, was carried out (e.g. Net-aporter, 2022; EASA, 2017; Hansen; 2017; Lee, 2016; DHL, 2022; Korosec 2016; Post and Parcel, 2017-a; Davidson, 2016; International post corporation, 2016; Ecommerce news, 2016; GLS Group, 2016; Cyclelogistics, 2017). The trends considered for the luxury industry in the Nordics are: Delivery apps, drones, autonomous vehicles, hyperloop, in-car delivery, delivery inside the house, parcel lockers, delivery to pick-up points, bicycle delivery and consolidate different orders (pantry). Of these methods apps, pick-up points and consolidating of orders are already used in the luxury industry of the Nordics (see Table 1). For some of these methods the technology/infrastructure is not yet ready. The star indicates that usage is primarily in multi-brand collaborations.

Trend	Application to the luxury industry		
	Already applied	Possible in the future: technology is ready	Feasible prior modification/further development of technology
Delivery apps	X*		
Drones			X
Autonomous vehicles			X
Hyperloop			X
In-car delivery			X
Delivery inside the house		X	
Parcel lockers		X	
Delivery to pick-up points	X*		
Bicycle delivery		X	
Consolidate different orders (Pantry)	X*		

Table 1: Potential application of delivery methods to the luxury sector

Besides the technological development, these delivery methods are also influenced by how the given customer segment and country view the option in terms of safety, likely cost, the available infrastructure, and convenience.

METHODOLOGY

This research is explorative and thus the case study approach was selected. The case company, called Nordic Coffee for confidentiality reasons, was selected based on several criteria, including 1. Operating in the Nordic market, 2. Being a luxury food and/or beverage producer, and 3. Access to data within the company, its delivery partners and to its customers.

In addition to the case study, benchmarking is chosen as a method to compare and learn from the best-performing actors (Jarrar and Zairi, 2001).

The empirical data for this research was collected through semi-structured interviews with key stakeholders across multiple departments and internal documents from Nordic Coffee. Furthermore, a customer survey of customers of the case study was carried out. Finally, the key delivery companies operating within the business area of the case company, including those already used by the case company, were also investigated in terms of their delivery methods. The different data collection methods and benchmarks carried out in this study is shown in Figure 1.

Figure 1: Research structure

RESULTS

Nordic Coffee produces high quality coffee, in capsules, and coffee accessories (e.g., chocolates, machines and cups). The company is considered a leading luxury brand within consumer coffee, with offices across the world, including the Nordics.

Current delivery methods

For all four countries consumers can get some updates on delivery using an app/phone; however, the details given and how often an update comes, varied between country. In Sweden, Norway and Finland pick-up points are extensively used, while Danes also appreciate home delivery. As an alternative, customers in Denmark and Finland also choose automatic parcel lockers, but there are few parcel lockers in more rural areas of Norway and Sweden. At the moment, only customers in Denmark can benefit from a flexible delivery: if the recipient is not home, the parcel can be left on the doorstep or brought to a neighbor, if requested. Boutique pick-up is used by customers in all four countries. These preferences follow general delivery preferences found in studies done by delivery companies for the Nordic countries (PostNord, 2021).

Customer satisfaction on current delivery services

A survey of customer satisfaction and customer needs for the case company was carried out for each of the four countries. All customers who brought products within a specified two months where this customer study took place, were offered to take part, getting a gift/free product by doing so. Between 25-45% replied to it in the four countries. Customer complaints regarding delivery could be clustered into four groups: 1. Late delivery, 2. Lost package, 3. Package arrived damaged and 4. Wrong products arrived.

Comparing identified customer needs for luxury companies found during the literature review and external benchmark with what is currently offered by Nordic Coffee (AS-IS) and what the customer survey done at Nordic Coffee indicate the customers want (TO-BE), it can be seen that some of these needs are quite well covered and some are not currently covered (see Figure 2).

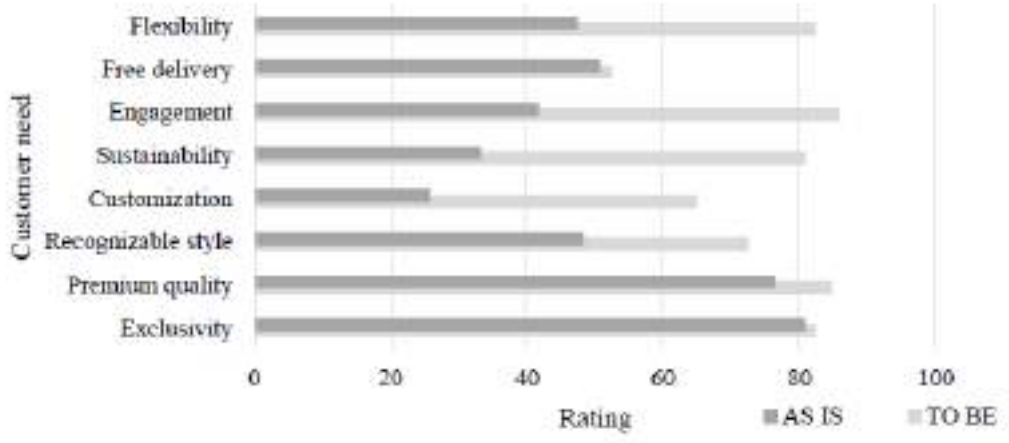

Figure 2: Comparison between customer needs and their desired level (TO BE) and current level (AS IS)

The needs which are well covered are free delivery, quality, and exclusivity. Least covered are flexibility, engagement, sustainability, and customization.

ANALYSIS

The benchmarked delivery options are listed in table 3, with their corresponding customer needs, identified above.

Delivery mode	*Satisfied needs*	*Additional benefits*
1-Outsourced app	Accurate tracking, customer engagement, customization	Quick delivery
2-Corporate app improvement	Accurate tracking, customer engagement, customization	
3-Parcel lockers	Flexibility and proximity	
4-In-car delivery	Effortless delivery, flexibility	
5-Smart lock	Effortless delivery, flexibility, customization	
6-Bicycle deliveries	Sustainability	
7-Pantry	Sustainability	Aggregate online orders
8-Flexible delivery	Flexibility	
9-Accurate delivery	Flexibility	
10-Autonomous vehicles	Sustainability	Innovation
11-Drones	Sustainability	Innovation

Table 3: Potential delivery services and corresponding satisfied needs

The delivery options were presented to the case company. Stakeholders from several departments were interviewed and ranked the options from 1 to 5 with 1 being the option should be avoided, 3 was likely implementation and 5 was must be implemented now. The average rating and standard deviation of the responses were calculated, showing that app improvement, bicycle delivery and other sustainability aims, initiatives to focus on flexible delivery and accurate delivery were scored the highest, with using an outsourced app, parcel lockers, in-car delivery, smart lock, pantry, autonomous vehicles and drones scored significantly lower.

To get a more detailed picture of the internal results, the scattered distribution of these distribution alternatives was also scoring according to the Nordic Coffee department they worked in: B2B, customer service, CRM, E-commerce, Finance, Supply chain management, TQM, Marketing and top management. Corporate app improvement and flexible delivery is considered main priorities by the stakeholders overall. Accurate delivery is also a vital focus area, mainly due to the priority given to this by the B2B and customer service departments. The fourth most preferred alternative is bicycle delivery.

The preferred delivery options in Nordic Coffee were also investigated by country, instead of department (see Figure 3).

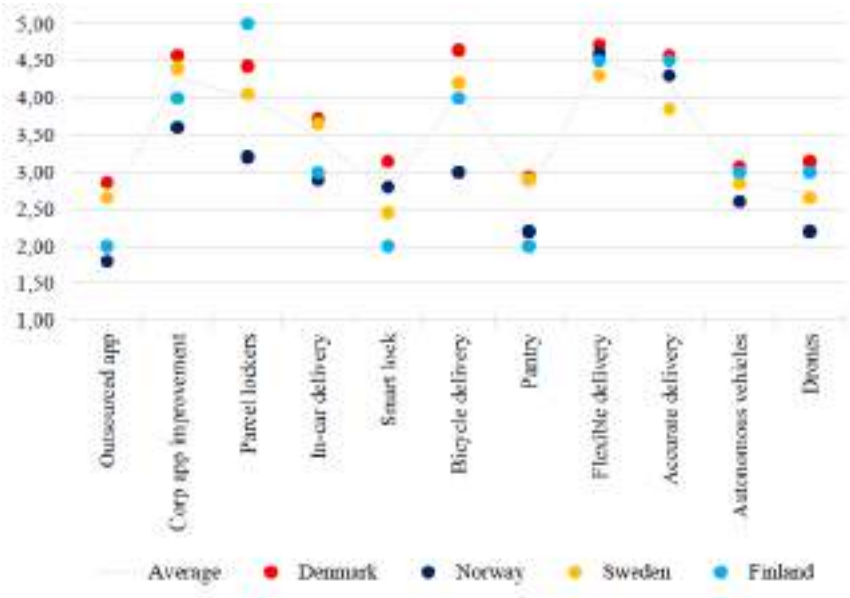

Figure 3: Alternatives rated per country, average scores

Corporate app improvement scores high in Sweden and Denmark, but less in the other countries, likely because in these the distribution partner already sends the customer regular email and SMS updates. Bicycle delivery and other sustainability options also differs among countries, likely due to difference in current use of bike messengers and other sustainability initiatives.

DISCUSSION

Based on these results from Nordic Coffee and the customer needs survey, the suggested improvements can be separated into four areas: Customization, Sustainability, Customer engagement and Flexibility:

- Customization: Customize the online shopping experience, including shipping options
- Sustainability focus: Bicycle delivery option and online buying options (e.g., carbon offset)
- Customer engagement through regular updates from the delivery company with app, online tracking etc.
- Flexibility: Partner with different delivery companies to ensure a flexible and accurate delivery which allows for various options, including home delivery, delivery to a locker, delivery to a shop, delivery to a neighbor etc.

Based on this, an action plan for Nordic Coffee was created, divided into two parts: the tasks that enclose the entire Nordics (maintenance plan and improvement plan) and the country-specific elements needed due to the identified geographical differences. Figure 4 show some highlights from the action plans.

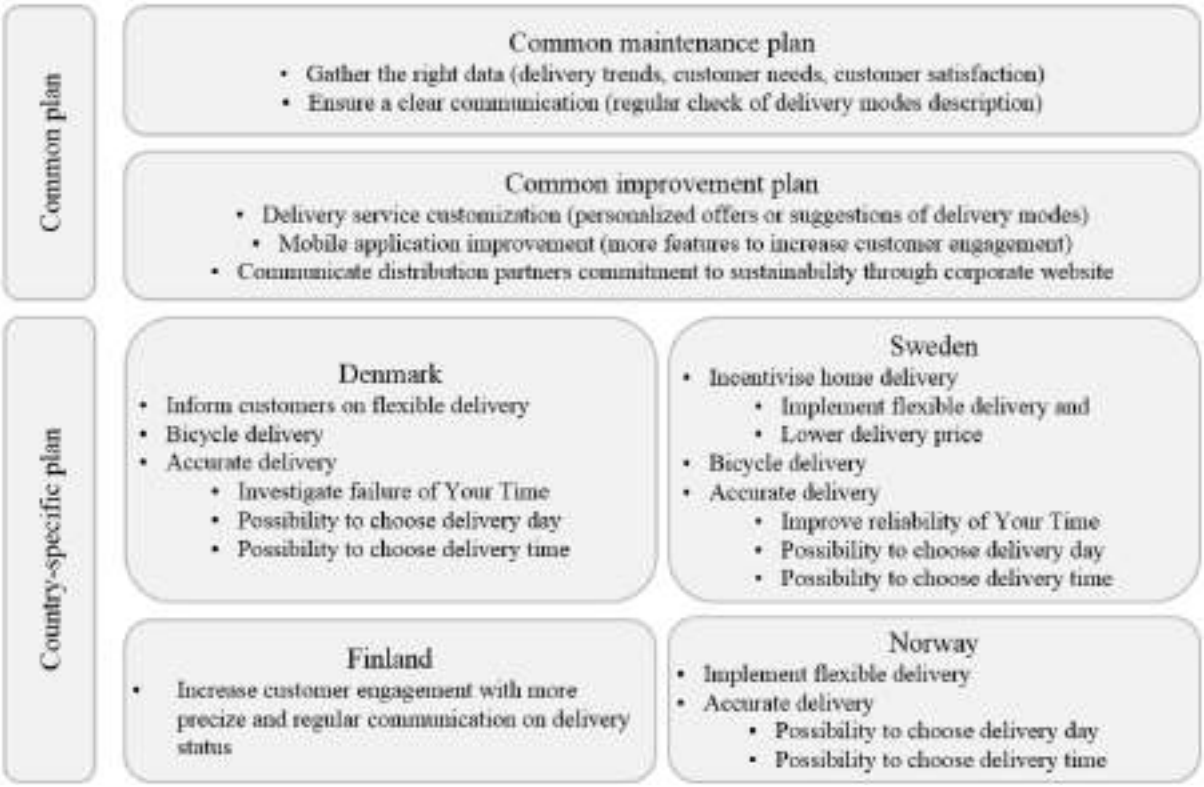

Figure 4: Highlights from the common and country-specific elements of the improvement plan for Nordic Coffee

To ensure a durable and sustainable progress on delivery services, the action plan should be continuously adjusted as needs and conditions change. Hence, a framework was developed for this purpose.

FRAMEWORK

Based on the conducted research, a 12-step framework has been created which describes how Nordic Coffee and other luxury firms can stay up to date on delivery methods and select the right ones for their business. These steps are shown below:

1. Conduct market research and stay up to date with latest trends.
2. Identify customer segments and explore customer needs.
3. Assess current delivery services in use and their fit with the customer needs.
4. Involve all key stakeholders, internal and external, to brainstorm potential improvements of the current delivery services.
5. Identify the possible future delivery services which are relevant when compared to the identified customer needs.
6. Evaluate each delivery option through a detailed internal analysis involving the key stakeholders, ranking these, and providing pros and cons of implementation.
7. Critically analyse and evaluate the results.
8. Based on the above analysis, select the improvements to current delivery services, the closure of current delivery services and new services to be implemented.
9. Conduct a cost/benefit analysis, risk analysis and calculation of necessary resources for each suggestion/change.
10. Contact distribution providers and get detailed information so a cost/benefit analysis for each can be carried out (if delivery is not done in-house).
11. Select the most suitable external partner (if delivery is not done in-house).
12. Create a detailed implementation plan.

These steps should be updated and maintained on a regular basis based on feedback and input collected from suppliers, customers, market research, benchmarking etc. The key stakeholders from the company should meet and discuss the logistics regarding delivery methods, using the proposed framework, on a monthly basis, to ensure continued alignment and fit as new information becomes available.
Contractual commitments, a lack of resources and other company specifics may restrain some options. Therefore, companies can spend less time on some steps or skip steps if they are not relevant for their situation, using the framework flexible as their environment and situation changes. An example of using and implementing this 12-step framework was illustrated through Nordic Coffee.

CONCLUSIONS AND NOTES FOR FURTHER RESEARCH

The luxury sector has seen rapid growth in recent years and are characterized by unique customer needs. There is a need for careful and systematic evaluation of new distribution trends to ensure a continued fit. However, there has been limited research into the selection of distribution channels for this specific industry. When focusing on the growing luxury food market, this gap is even clearer. This paper has therefore focused on addressing this research gap.
As this is an explorative study, a case study approach was adapted. A literature review followed by a benchmark identified the delivery trends and market needs relevant to the luxury industry. A customer survey for the case company was carried out to identify customer needs. An internal interview round across multiple departments and all four Nordic countries wherein the case company operates, were also conduced. The findings showed that improvements can be separated into four areas: Customization, Sustainability, Customer engagement and Flexibility. Based on the data from the case firm, improvement suggestions were given both overall and for each of the four Nordic countries, to allow for the geographical differences observed during the study.
Finally, a 12-step framework was developed for how a luxury food company can ensure continued alignment and fit in regard to delivery methods and trends. This framework should be considered cyclic and continuously adapted as new information and feedback becomes available from customers, suppliers, market research etc. The framework was validated by the management of the case company. The improvement suggestions considered 'here and now' options had been implemented after six months. Almost a year after the study had been concluded, the case company reported they still used the 12-step framework to ensure they stayed updated and aligned on delivery trends.
Further research should implement the framework in other companies within this sector and other sectors of the luxury goods business as well as within other geographical regions. The differences and similarities between regions and luxury goods markets could prove valuable in further developing the framework. Moreover, the scalability of the framework compared to type of luxury goods companies, geographical area and other characteristics could prove of interest. Finally, the differences and similarities to other industries could also give new insights.

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Manufacturing Logistics

Commercial games for education in production logistics: an analysis of the game production line ©

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INTRODUCTION

In higher education and training, game-based learning (GBL) is a known approach to enhance learning environments in many different domains (Mayer *et al.*, 2014; Duin *et al.*, 2011; Baalsrud Hauge *et al.*, 2014). Games allow for experimenting in a safe environment, what explains their attractiveness for education. However, a regular challenge for trainers and educators is the availability and attractiveness of serious games that are designed with learning purposes in mind. Therefore, commercial-of-the-shelf (COTS) games are also taken into consideration when selecting games for GBL (Becker and Gopin, 2016).

In a selected course at Wiesbaden Business School, and in coordination with other European institutions of higher education, the COTS game Production Line© has been selected for closer analysis (Kalverkamp *et al.*, 2022) and was consequently used on a trial basis in a logistics course in the winter term 2022/23. Production Line is a single-player game that simulates a modern car factory. Kalverkamp *et al.* (2022) evaluated the general applicability of the game in education on production logistics based on a high-level analysis and in light of the intended learning objectives (ILOs) from respective university courses.

This study analyses the game at a more granular level of the logistics processes with the objective to understand how typical learning content from operations management is represented by the game. Thereby this study contributes to the questions what specific problems students are supposed to solve in the game, how they may be solved, and hence what learning content can be addressed. In addition, this study asks how data can be used in the game and to what degree facilitator support is required to align the theory with the players experience in the game. Ultimately, this study aims to support facilitators who want to use the game in their classroom to enhance instructional strategies and to design the instructions in a way that learners are supported during their learning journey.

After briefly outlining the use of games in education and Kolb's learning cycle to create experiential learning environments, the methodological approach is explained before highlighting the results of the game analysis. The discussion section focuses on the findings on game functions relating to production logistics while also connecting those with some insights from the initial application of the game. The study closes with on outlook on next steps.

LITERATURE

Serious Games in Education on Logistics

Conveying skills in a conventional setting is difficult in SCM education, hence alternative methods are being investigated. One of such are serious games and GBL environments. Serious games are considered entertaining but with non-entertaining objectives (Becker and Gopin, 2016; Baalsrud Hauge *et al.*, 2014) and are more commonly used in higher education nowadays (Gómez and Suárez, 2021).

Amongst the advantages of serious games is their ability to enable learners to experience situations in simulations that would not be fully possible in real life for financial, time and safety reasons, as well as the visualisation of learning content (Squire, 2003; Mayer & Kriz, 2010). Other benefits include increased motivation (Warmelink *et al.*, 2020), improved strategic thinking (Gómez and Suárez, 2021) and a more positive mood in general (Zhonggen, 2019). Another positive effect is the familiarisation with the digital world and the accompanying preparation of the young generations for the constantly changing and complex digital future (Lukosch *et al.*, 2016; Baalsrud Hauge *et al.*, 2014).

Despite the advantages linked to GBL, negative aspects are acknowledged and should be examined when considering the use of games in education. One of such is the time and effort required to understand and use games (Becker and Gopin, 2016) as well as the degree of complexity of the game (van Eck, 2008). A high workload or overly complicated game can hinder the learning process due to excessive demands and have a detrimental effect on the overall outcome (Zhonggen, 2019).

The ability to provide a protected space for both experimenting and experiencing is an essential aspect because of which games are used in education. The GBL environment can thus provide a combination of problem- and practice-based instruction, creating learning opportunities that enhance critical thinking without the risk of negative effects in the real world. However, this requires sensible planning and application, such as the coordination of the game and the teaching concept (Baalsrud Hauge et al., 2015). For example, the players should also always have a goal in mind (Susi *et al.*, 2007) and the game should not be designed to be too complex (Baalsrud Hauge *et al.*, 2014). At the same time, learning should go beyond just theoretical models and extend to their application in realistic scenarios. However, reflection on the effectiveness of these models is crucial (Duin *et al.*, 2011; Wood and Reiners, 2012). It is important that players and facilitators conduct feedback and analysis of the gaming experience to ensure that skills are solidified (Baalsrud Hauge *et al.*, 2014; Squire, 2003; Zhonggen, 2019).

Commercial Games for Game-based Learning

The discussion on games in GBL includes the use of games that were primarily designed for entertainment purposes but involve curriculum content hence may have educational potential (van Eck, 2008). This indicates one of the assumed advantages of using COTS games, namely their engaging and entertaining character. However, using COTS games requires teachers to being able to identify suitable games and to adopt the game to the GBL course (Becker and Gopin, 2016; van Eck, 2008).

Creating a course that effectively incorporates a game requires a thorough understanding of how the game integrates instructional strategies, objectives, assessments, and other educational elements (van Eck, 2008). Developing successful COTS GBL is a complex process, similar to designing any effective educational material (van Eck, 2008). Frameworks exist to support the identification and selection process of COTS games (Becker and Gopin, 2016). Furthermore, van Eck (2008) proposed to follow the NTeQ model for technology integration to design a course that integrates a COTS game. The model covers different aspects relevant to the integration, such as the specification of objectives and the problem(s) to be solved as well as activities before, during and after the use of the game. For this study, the aspects of identifying and evaluating an appropriate COTS game are relevant, this requires that the teacher properly understands the game to develop a course plan and assessment around it (Becker and Gopin, 2016; van Eck, 2008).

Serious Games, Kolb’s learning cycle, and the PDCA cycle

As outlined, a game itself does not make for an effective GBL environment. For GBL environments, Kolb’s learning cycle has shown good results. Kolb's learning cycle (Baalsrud Hauge et al., 2015) offers an approach for understanding the positive effect on learning success. The model focusses on experimental learning as an alternative learning process full of conflicts (Kolb, 1984). Specifically, it is a cycle that is divided into four phases or learning mechanisms that are repeatedly passed through during learning (Eckert, 2020). It also covers four learning styles and consists of two opposing modes for receiving experience, concrete experience, and abstract conceptualisation, and two opposing modes for processing experience, reflective observation, and active experimentation (Kolb and Kolb, 2005). Learners prefer different learning styles though most relevant for this study is "[...] that learners improve their performance when they go through all four modes in learning" (Eckert, 2020, p. 25). The advantage of using games is the ability to enhance the experiential part of Kolb’s cycle.

Similar to Kolb’s cycle, the PDCA cycle is a well-known method in operations and logistics used to improve processes and achieve continuous improvement. It involves four steps: Plan, Do, Check, and Act. The cycle is designed to help organizations or individuals identify and solve problems, and to continuously improve processes and performance (Deming, 2018). As their names indicate, both methods are of cyclical nature and put emphasis on reflection and evaluation. Both Kolb's learning cycle and the PDCA cycle involve a continuous loop of action, reflection, and adjustment. In Kolb's model, reflection on experiences is key to gaining new insights and adapting to new situations. In the PDCA cycle, checking and evaluating results is crucial to making improvements and refining processes. While the two cycles have different objectives, they share common elements that emphasize the importance of reflection, evaluation, and adaptation in the learning and improvement process (Verna, 2020, pp. 82–83).

METHODLOGICAL APPROACH

This paper analyses the game Production Line© with the objective to identify logistics processes and hence learning contents that are in alignment with the learning objectives of production logistics in general and a selected higher education course offered at Wiesbaden Business School. The approach consists of three phases. The first phase involves identifying relevant learning contents based on the syllabus and assessing their potential representation in the game at a general level. In the second phase, an iterative approach is used to analyse in more detail the items assumed to be represented in the game, similar to the learning journey intended for course participants. Finally, the intended learning journey is transformed into a course curriculum, which is conducted and evaluated. While this study focuses on the results of the second phase, the discussion section provides insights from the third phase.

The initial phase covered some of the general considerations that are relevant when applying a COTS game in GBL. The focus was on the course syllabus and its ILOs (see Kalverkamp *et al.*, 2022 for details). For this study, the course on logistics and operations at Wiesbaden Business School is relevant, with ILOs focussing on the analysis of production processes and respective improvement measures, the application of solutions, and critical evaluation of the results. The respective theory relates to, for example, Little's law; lead, cycle and takt times; capacities; and value stream mapping. These are especially relevant for process analysis in general and similarly for the analysis presented here.

After the initial analysis, the second phase focussed on analysing the game in more detail. Previously, a simple production setup was built to test some of the game's functionalities. Developing a factory layout, assessing performance, identifying potential solutions, and eventually adopting strategies to improve performance are tasks essential to the game and relevant to the ILOs. In addition, these tasks allow to resemble the PDCA cycle hence to establish a GBL environment following Kolb's learning cycle (see section 2). This phase analysed whether and how the theory identified in the first phase is implemented in the simulation and how it can be applied based on the available information. The PDCA cycle was adopted for this analysis to suit the simulation, where measurements in the Plan phase are tested in the Do phase, followed by reviewing key performance indicators (KPIs) in the Check phase, and conducting lessons learned and documentation in the Act phase as well as making short-term improvements, if necessary.

In the last phase, the results from the game analysis, including a gameplay focussing on the game experience itself, were translated into a course design and the latter tested with 4th semester undergraduate business management students. The course and the game were evaluated separately and anonymously by the students, and in a lessons-learned format in the classroom. In addition, the authors who also conducted the course and/or respective training sessions reflected on their observations and findings.

RESULTS

The Game and Scenarios

Production Line has been identified as the COTS game to be used in the outlined course (see Literature and Methodological Approach). The game is a building simulation (within the 'tycoon' genre) focussing on the production line hence the tactical-operational level of the factory. Its objective is to build and run an increasingly efficient production line.

Furthermore, the game provides various playing options that can influence the player's decision-making process. Most relevant is the scenario mode, where the player is given a set number of vehicles of specific car types (e.g., budget, mid-range, luxury) that must be produced within a specific budget and time frame. The cars produced are then sold in the market, and the revenue generated is used to finance various aspects of production, including research and development of new vehicle technologies and improved production processes, such as specialized operations in the paint shop and the introduction of new robots to speed up the production.

The Analysis and Elements of Kolb and PDCA

The analysis of this study is based on a so-called 'freeplay' scenario without financial limitations to be able to concentrate on the technical analysis rather than other game mechanics. This is different to the setup for the classroom where students are supposed to start with an initial budget that limits their decisions while they have additional objectives.

The initial game set-up is presented in a tutorial where every production cell is built once. The cycle times vary significantly within the different production cells leading to production stops due to bottlenecks quickly. To optimise efficiency, it is necessary to synchronise the timing of all work steps, which enables a reduction or, ideally, elimination of waiting times and thus reduces the throughput time. Figure 4 visualizes the cycle times of each production cell following their order in the production line.

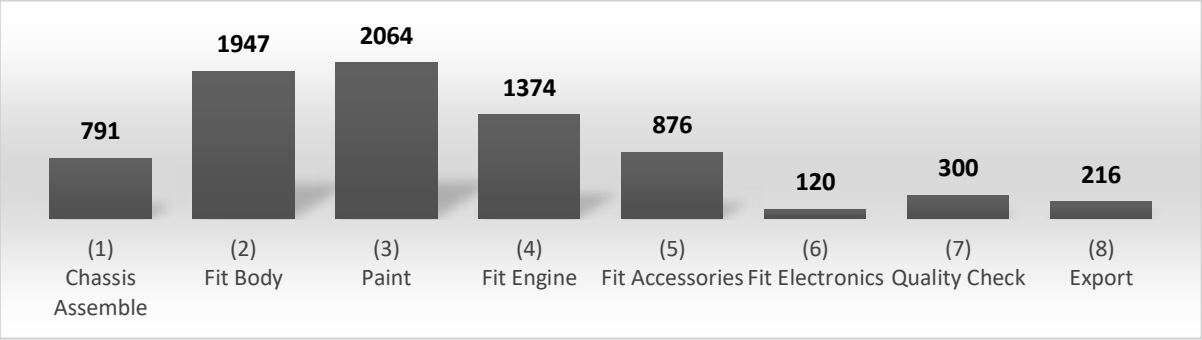

Figure 4: Cycle times per slot in seconds per order unit

The analysis follows an iterative approach to improve production efficiency gradually aiming to replicate the intended learning cycle. The planning phase includes the identification of the bottleneck and aims to set the same overall goal and hypotheses in every iteration. The general objective is defined as avoiding production congestion to reduce throughput and cycle time and thus increase production efficiency and reduce production costs. The throughput time of the individual production is used as a reference value. The actions taken are summarised in Table 2; the production slots are numbered as presented in Figure 4 and referred to by their numbers. In general, installing more equipment (i.e., production cells) as well as additional robot capacities is assumed to contribute to the achievement of the goal. Therefore, a) research is preconditioned on the robot upgrades allowing an increase of the speed of the production cells up to 27.5%; and b) the general evaluation process during the Plan phase is not detailed in the table. The process during this phase consists of identifying the bottleneck, comparing, and aligning cycle times up to the bottleneck. To give an example for the first Plan phase the throughput times of the production cells (1) to (3) are compared. While (1) takes 791 seconds to complete the task, (2) is done in 1947 seconds and (3) is identified as the bottleneck taking the longest with 2064 seconds. Planning from (1) on, (2) and (3) should be able to produce roughly within the same amount of time. When upgrading (2) with robots I, II, III and liquid cooled welding it will take 1527.06 seconds (+27.5 % in speed). By building two production cells of the same kind, throughput time will be cut in half resulting in 763.53 seconds on average. For (3) two additional cells must be built to achieve an average throughput time of 688 seconds. With throughput times of 791, 763.53 and 688 seconds respectively, the cells (1), (2) and (3) are better coordinated.

No	Plan	Do	Check	Act
1	- Bottleneck: (3) - Evaluating throughput, new production cells & robot upgrades (all iterations)	- At (2): build additional production cell & upgrade all robots (I, II, III, liquid cooled welding) - At (3): build two additional production cells	- Performance has improved - Goals were achieved - Hypothesis has been proven	- KPIs have been monitored

	- Align maximum capacities of (1), (2) & (3)			
2	- Bottleneck: (4) - Align maximum capacities of (1), (2), (3) & (4)	- At (4): build additional production cell	- Performance improved but less than expected, see countermeasures in Act phase - Goals were achieved	- Corrective countermeasures due to missing resources leading to production stops: apply research for faster resource delivery & build stock for (5)
3	- Bottleneck: (5) - Restructure factory to increase total capacity - Apply research for splitting up (3) into four different cells - Align maximum capacities of (1), (2), (3), (4) & (5) - Add stocks for (2), (4) & (5)	- At (1): Build additional production cell - At (2): Build two additional cells & upgrade to robots II, III & liquid cooled welding - Replace (3) with (3.1), two (3.2), (3.3), & two (3.4) +10% in speed (max. power drying) - At (4): build additional cell & upgrade all cells with robots I & II - At (5): build additional cell & upgrade w/robots I; upgrade initial (5) w/ robots II - Build stocks for (2), (4) & (5)	- Performance has improved - Goals were achieved - Hypothesis has been proven	- Splitting up the production cell has improved factory efficiency significantly

Table 2: PDCA cycle iterations and activities

During the PDCA iterations, process KPIs were monitored, such as minimum and maximum throughput times, throughput efficiency, work-in-progress (WIP), output rate, cycle and takt times. Although some values are provided via the game interface, it is important to note that most of these indicators must be calculated manually. Hence numbers are monitored and extracted (e.g., in a separate Excel file) because the game regularly updates details about the production (depending on the value on an hourly or permanent basis) and the player cannot review older data. Table 3 shows those indicators the authors calculated based on the learning objectives, in the upper part and how they developed from the initial setup until the end of the 3rd iteration.

In addition, financial KPIs were monitored (see lower part of Table 3). In the scenario used to collect data, component costs hardly fluctuate. Therefore, the value is used without further processing. Other values are instead a calculated average. To calculate overhead and capital costs, production costs and

produced units per hour are observed over a period of five hours. The average value of the number of units produced per hour multiplied by the overhead and capital costs incurred in the respective period provide the basis for calculation. Divided by the output rate, the average production costs per order unit are calculated. It must be noted that the results depend on the game scenario used; for example, the authors realized that in different scenario types (e.g., not freeplay) game mechanics seem to influence the component prices quite substantially.

KPIs	After initiation	After 1st iteration	After 2nd iteration	After 3rd iteration
Min. throughput time (h per OU)	2.14	1.42	1.23	0.96
Max. throughput time (h per OU)	9.94	21.20	19.20	4.55
Throughput time efficiency (in %)	21.53	6.70	6.41	21.10
Max. inventory (no of OU / WIP)	17	53	72	39
Output-Rate (OU per h)	1.71	2.50	3.75	8.57
Cycle time average (in minutes)	35	24	16	7
Cost per OU (in Dollar)				
Component Cost per OU	8.521	8.537	8.503	8.526
Overhead Cost (average) per OU	14.320	13.079	9.238	5.440
Capital Cost (average) per OU	3.692	4.014	2.968	2.266
Total Cost per OU	26.533	25.630	20.708	16.232

Table 3: Development of Key Performance Indicators over time

DISCUSSION

The game analysis shows that KPIs used in real life scenarios can be applied to the game. Moreover, once changes are made in the game following findings from the PDCA and the calculated KPIs, the game will adjust data correctly. The game provides plenty of data to be able to calculate KPIs for a learning environment. Data such as costs and throughput time are exact. However, other data such as cycle time needs to be counted manually. This and the fact that some measurements like the transport on the conveyors can hardly be taken into consideration for the manual calculation (no available data points) makes manually calculated KPIs less accurate. Although some KPIs are less accurate, they are sufficient to be used as indicators in a learning environment, provided that discrepancies can be explained. Furthermore, some KPIs like Slots Running are computed and readily available within the game interface.

The case of Slots Running shows the importance for both teachers and students to understand the composition of the KPIs. Teachers need to be able to explain especially the KPIs presented by the game. The calculation of Slots Running may not be obvious to students, as it includes every production cell and the resource importers. Yet the game does not show data for these importers, thereby undermining their relevance for the KPI. In addition, the KPI is updated frequently and only manually calculated averages result in representative measures. The game also provides a data graph for this KPI, which is a good tool to keep track of the factory's performance. Unfortunately, past information is not available, requiring frequent manual calculations and saving of screenshots. Especially in the early stages of the game, this KPI is volatile due to few production cells installed. A close supervision is therefore necessary for student learning and understanding.

The game is not only a good learning environment because data is presented realistically but also because it shows the importance of measuring multiple KPIs to be able to analyse the efficiency of the factory. While the maximum throughput time and the throughput time efficiency deteriorate during the first and second iteration, the minimum throughput time, output-rate and production costs are improving constantly and only in combination creating the full picture of the production's performance.

Despite these positive findings, some calculations by the game concerning the production cost remain vague and may have to be treated as a black box. Although it is important for teachers to understand everything, in case of the costs this does not have a negative impact on the understanding of the game from a logistics perspective. When comparing the development of the component cost between freeplay mode and the scenario mode, the authors found that costs fluctuated significantly in scenario mode making the production unprofitable at certain points in time. The game likely applies some game mechanics in the scenario mode to keep the player engaged, which is considered positive by the authors as this is one of the reasons to use (COTS) games. However, teachers must take these observations into account when using the game.

The freeplay scenario was a good choice for data gathering in this study focussing on the analysis of outcomes of decision-making in the game and respective results in terms of KPIs. For the GBL environment where the game was tested (3rd phase), the authors used a scenario that defined a specific number of vehicles to be produced in time while limiting initial funds. Thereby, the ILO on process analysis is indirectly linked with a game objective taking advantage of the game functions and mechanics in order to increase motivation and engagement. Using an iterative, continuous improvement approach may be obvious to a logistics professional, although without budget limitations one would likely initiate the factory redesign even faster because of the obvious process inefficiencies. However, the outlined analysis aims to resemble a learning cycle for students as well as the approach to utilise the PDCA cycle as a tool for process improvement. This leads up to the outlined iterations wherein bottlenecks are identified step-by-step. An iterative approach has also been used to teach the students in class. Nevertheless, it is important to structure the class well and make sure students are not overwhelmed and are able to keep track of their goals. Teachers need to supervise closely to ensure full understanding and avoid confusion caused by non-transparent game mechanics.

As outlined, in the third phase of the analysis and implementation process, the game was introduced to a GBL on production logistics to train students in process analysis and improvement. In addition to the outlined process indicators, the GBL addresses different tools from logistics such as value stream mapping (VSM). This setup allowed the students to apply VSM to a dynamic environment instead of a text-book exercise. Initial findings from the classroom indicate that the game provides an entertaining and engaging environment for students to experience and learn the challenges of production logistics. However, the course design also revealed some limitations mainly related to the achievement of ILOs, which required more facilitator intervention than initially assumed. Accordingly, and in the spirit of continuous improvement, timings of certain exercises will likely change, and tutorials will be split to provide more and smaller iterations and hence to further strengthen the idea of the PDCA and the learning cycle. Game features such as save games may be used in this context to enhance the learning by providing students with predefined game setups reducing required playing time to reach similar situations.

CONCLUSION AND OUTLOOK

While providing attractive opportunities to enhance classroom experience, the use of COTS games in GBL requires facilitators to develop sufficient understanding of the game prior to application. The presented study findings demonstrate how Production Line© can be adopted to GBL on production logistics. General theory can be applied to the game and process analysis and improvements are presented in a comprehensible way that is in line with theory. However, sudden cost fluctuations are one example for effects that require explanations. Therefore, the findings also show the importance to properly assess and analyse a COTS game selected for GBL. Course facilitators must be aware of game functions and (some of) the effects of the game mechanics to better isolate causes for certain results and explain them to the participants.

Based on this study's findings, the game Production Line© was used in a GBL environment. In general, findings from this course support and extend those presented in this study, though provide insights on improvement potential such as the overall course design. The authors will utilise these findings to further improve the use of the game.

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