Exploring Digitalization, Resilience, and Sustainability Challenges in the Cargo Transportation and Logistics Industry through Topic Modelling and Empirical Evidence in the Aftermath of COVID-19

KAYIKCI, Yasanur <http://orcid.org/0000-0003-2406-3164>, SUBRAMANIAN, Nachiappan and KUPPUSAMY, Saravanan

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Abstract

The COVID-19 pandemic has resulted in unprecedented disruptions, making the planning and management of cargo transportation and logistics challenging. The growth of e-commerce has added considerable pressure to logistics capacities, while the lack of contingency planning and unclear information about the situation has made accessing necessary supplies difficult. In our research, we have developed an approach that combines topic modelling analysis, semi-structured expert interviews for empirical data collection, and the concept of a theory of change. This approach aims to: (i) identify critical areas of concern; (ii) determine short- and long-term mitigation measures for each identified critical area for establishing stability and interpretive mechanisms through digital technologies; and (iii) propose practical solutions for establishing resilient supply chains through a robust supply chain framework. Our comprehensive approach provides an accurate assessment of the challenges faced by the industry, highlights the critical areas of concern, and offers practical solutions for the post-COVID-19 cargo transportation and logistics industry.

Keywords: Digitalisation; Resilience; Theory of Change; Robust Supply Chain Framework; Mitigation Measures

1. Introduction

The cargo transportation and logistics industry plays a crucial role in facilitating international trade by handling the storage, delivery, and distribution of goods and services, as well as other tasks such as border crossings, port movements, customs clearance, documentation, and administrative duties. In the past, the industry has encountered disruptions caused by conflicts, trade disputes, exchange rate fluctuations, and natural disasters (Fox et al., 2020; Kayikci, 2021; Wankmüller, 2021; Singh et al., 2021). Companies have responded to these challenges through various strategies, including forming strategic partnerships (Bygballe et al., 2023), relocating production to different countries (Kleindorfer & Saad 2005), or utilising currency derivatives (Katsaliaki et al., 2021). However, the COVID-19 pandemic has had an unprecedented impact on the cargo transportation and logistics industry, unlike any other disruption (Seifert & Markoff, 2020; Del Rio-Chanona et al., 2020; Xu et al., 2020), presenting challenges throughout the entire supply chain. While wider supply chain studies may include cargo transportation, our research focuses primarily on this industry. Its vital role in global trade, combined with its exposure to different supply chain touchpoints and dependencies, renders it particularly vulnerable to disruptions. The above studies state how firms respond to disruption, but it is not so evident that the engagement of specific mechanisms with the support of technology that paved the way to changes and to shape the response is very limited. The aim of our research is to understand the impact of the COVID-19 pandemic on the cargo transportation and logistics industry, and to understand the interventional strategies that fortify the industry against future disruptions.

The pandemic has resulted in a decline in freight demand, leading to a series of logistical issues including empty runs, cancelled shipments, labour shortages, and unaddressed bottlenecks in logistics due to insufficient technology (Bombelli, 2020; Fox et al., 2020; Ivanov, 2020a, b; Mahnken, 2020; Cerasis, 2020; Cognizant, 2020; Queiroz et al., 2022; Javaid et al., 2020). Last-mile delivery has been affected by the pandemic as businesses struggled to adapt to the shift towards online purchases. Stringent regulations have resulted in shortages of trucks and drivers, cross-border closures, and extended waiting times, impacting cargo handling, causing shipment delays, and raising the cost of goods (Choi, 2020; Cordon & Buatois, 2020; Ivanov, 2020b; Bombelli, 2020; Kumar, 2020). Infrastructure challenges and inadequate technology have led to cargo losses, damages and delays. These issues highlight the industry's lack of preparedness and mitigation strategies (Doherty & Botwright, 2020; Xiao & Fan, 2020; Twinn et al., 2020; Russell et al., 2022; de Sousa Jabbour et al., 2020).

Our research addresses these challenges and provides insights for the cargo transportation and logistics industry on how to mitigate and recover from system-wide disruptions such as COVID-19 using advanced technologies to ensure buffering and bridging responses. Buffering involves implementing protective measures through partnerships, safeguarding a firm from disruptions. Conversely, bridging entails building trust and capacity with external partners to manage uncertainty (Bode et al., 2011).

The multifaceted issues generated by the COVID-19 pandemic have underscored the essential role of digitalisation, sustainability, and resilience within cargo transport and logistics networks. Digital technologies, for instance, bolster end-to-end visibility via real-time monitoring of workforce health and psychology. These factors proved to be crucial during the pandemic for ensuring stability among inter-firm relationships. In addition to these key benefits, digitalisation empowers stakeholders to rapidly respond to changes, streamline processes, reduce costs, and share prior experiences gone through during disasters (Wang and Sarkis, 2021). The concept of dynamic capacity can equip companies to navigate unexpected and hard-to-quantify incidents through bridging and buffering responses, thereby enhancing resilience within cargo transport and logistic networks (Yu et al., 2019). Moreover, the broad societal and economic impact of the pandemic has triggered the worst economic crisis since the Great Depression. This crisis has fundamentally impacted all Sustainable Development Goals (SDGs) set to be achieved by 2030 (Gopinath, 2020; Karunathilake, 2021). Considering this reality, sustainability policies are gaining prominence as a crucial tool to address disruptions instigated by unforeseen events such as the pandemic (Klein et al. 2022). There are some studies, such as those by Belhadi et al. (2021) and Cherrafi et al. (2022), that have examined the challenges and response strategies associated with the pandemic. However, these contributions primarily focus on manufacturing sectors and broader supply chain management (SCM) issues, leaving the specific topic of cargo transportation and logistics industry transformation and the role of technology to support buffering and bridging responses through inter- and intra-firms underexplored.

Existing research has explored the individual aspects of supply chain resilience, sustainability, and digitalisation, particularly in response to global disruptions such as the COVID-19 pandemic. Key contributions include:

- conceptualising a digital twin framework for managing disruptions (Ivanov and Dolgui, 2021);

- analysing barriers to digitalisation (Gupta et al., 2022);
- prioritising digitalisation in response strategies (Pujawan & Bah, 2022);
- leveraging logistics services providers' expertise to enhance resilience (Hohenstein, 2022);
- improving supply chain resilience (Mishra et al., 2022);
- demonstrating how resilience mediates the relationship between digitalisation and performance (Zhou et al., 2023);
- enhancing both resilience and long-term sustainability (Montaya-Torres et al., 2021);
- focusing on collaboration to bolster resilience (Dovbischuk, 2022); and
- enhancing supply chain security and resilience (Bechtsis et al., 2022).

Despite these advances, a gap remains in the literature regarding the integration of supply chain resilience, sustainability, and digitalisation—three components crucial for the long-term viability of supply chains (Ivanov, 2020a, b). This research therefore aims to address this gap, contributing to a broader understanding of these vital elements within the cargo transportation and logistics industry.

Given the importance of these challenges, a thorough understanding of the disruptions and targeted mitigation measures is required. However, the industry's problems are complex, and a one-size-fits-all solution could overlook vital aspects or result in misallocated resources (Perego et al., 2011). Therefore, it is essential to identify the critical areas requiring immediate attention to maximise the impact of efforts and resources. Failing to identify these areas could exacerbate existing problems, result in the failure of intervention strategies, and slow the recovery process. Once the critical areas are identified, it is equally important to implement suitable short-term and long-term measures (Belhadi et al., 2021). The necessity for distinguishing between these measures stems from their distinct functions. Short-term measures typically address immediate issues and help stabilise the current situation through the use of digital technologies to underscore the role of buffering and bridging responses. Meanwhile, long-term measures aim to enhance resilience and prevent similar disruptions in the future by managing the paradox among bridging and buffering responses within and across firms (Wu and Pagell, 2011). Finally, given the dynamic and interconnected nature of supply chains, identifying critical areas and implementing suitable measures are likely to contribute to the creation of a more robust and resilient supply chain (Cherrafi et al., 2022). This approach is important in today's rapidly

evolving business environment, where disruptions have become more frequent and varied in nature.

These premises led to the formulation of our three research questions:

1. Given the impact of COVID-19, which critical areas within the cargo transportation and logistics industry have been the most affected and require immediate strategic intervention with the support of digital technology?

2. What targeted short-term and long-term measures, related to buffering and bridging responses, can be implemented to alleviate the impact of similar future disruptions in these critical areas?

3. How can the integration of these critical areas and the blending of bridging and buffering responses to ensure stability within and across firms, through the support of digital technologies, contribute to the development of a more robust and resilient supply chain, specifically within the cargo transportation and logistics industry?

In this paper, we address the above questions using a hybrid methodology that incorporates three distinct components. First, we use topic modelling, a text mining approach, to identify critical areas of concern within the industry, allowing for a comprehensive understanding of emerging themes that may have otherwise been overlooked (Nikolopoulos et al., 2021; Ivanov, 2020b). Second, we conduct semi-structured interviews with experts and stakeholders from the industry. Through these interviews, we gather insights to determine both short-term and long-term measures tailored to each critical area identified. The third component involves leveraging the theoretical framework of Lewin's three-stage model of change (Lewin, 1958) and organisational response model to supply chain disruption (Bode et al., 2011). These are critical in implementing the changes necessary for more robust and resilient supply chains. By combining this framework with the insights from text mining and interviews, we create a plan to build resilience and develop practical digital solutions. Our approach results in several recommendations, including the development of a focused freight transportation strategy to help businesses adapt to changes, the enhancement of post-COVID-19 preparedness through digital technologies for real-time tracking, and the formation of value-based freight coalitions to improve collaboration.

From a theoretical perspective, our study contributes to the existing literature by bridging research gaps in cargo transportation and logistics. Current research often narrows its focus to

specific areas such as policies or regional concerns (e.g., Lau et al., 2020; Yang et al., 2021), limiting broader application. Existing studies highlight the importance of digital transformation, resilience, and collaboration (e.g., Hohenstein, 2022); however, a deeper exploration aligning with modern challenges, such as pandemics, is needed. This study's emphasis on digitalisation and collaboration addresses this gap. On the practical side, our study offers implications for enhancing supply chain practices, promoting technology, and improving resilience and sustainability. The examination of resilience, sustainability, and digitalisation in SCM during disruptions, as evidenced by Kumar et al. (2023) and Ivanov et al. (2019), yields actionable insights for operational improvements. Furthermore, the focus on short- and long-term measures, digital platforms for cargo booking, and real-time end-to-end visibility holds potential for cargo transportation practitioners, aiding them in mitigating the impact of disruptions. Insights into collaboration, adaptability, and recovery during a pandemic (e.g., Dovbischuk, 2022) underscore the potential for forming value-based freight coalitions, thus enhancing industry resilience.

The rest of this paper is organised as follows: Section 2 provides a thorough review of the relevant literature. In Section 3, we delve into detail about topic modelling and its application in identifying critical areas in the cargo transportation and logistics industry. Section 4 describes the empirical data collected through expert interviews, and the findings are analysed to determine short-term and long-term mitigation measures for each critical area identified in Section 3. Section 5 outlines a framework for a robust supply chain, incorporating the critical areas and mitigation measures from the previous sections. Finally, Section 6 concludes the research with theoretical and practical implications.

2. Literature Review

Our research explored digitalisation, resilience, and sustainability challenges in the cargo transportation and logistics industry in the wake of COVID-19. We used a mix of topic modelling, expert interviews for gathering real-world data, and a theory of change framework. Further details about the research related to these individual methodologies will be presented in subsequent sections. In this literature review, we focus primarily on two interconnected areas: (i) studies relating to cargo transportation and logistics during the COVID-19 pandemic, and (ii) studies on digitalisation, resilience, and sustainability in SCM, especially when disruptions occur. We aim to highlight how our research contributes to and enhances the current understanding in these areas.

2.1 Cargo Transportation and Logistics during the COVID-19 Pandemic

The research conducted in the field of cargo transportation and logistics during the COVID-19 pandemic has been limited. This is primarily because the focus has been predominantly on SCM, which encompasses a broader range of functions, including logistics. The COVID-19 outbreak had a profound impact on all aspects of the supply chain, making it challenging to examine the cargo transportation and logistics industry in isolation.

Several studies have explored the dynamics and challenges in the field of cargo transportation and logistics during the COVID-19 pandemic, with many focusing specifically on China. Lau et al. (2020) investigate emergency logistics in China, a crucial aspect of disaster and public crisis management. Analysing focus groups from Wuhan, Shanghai, and Xian, they pinpoint success factors such as demand forecasting, inventory management, and distribution network design within emergency logistics. While the study offers valuable insights into emergency logistics, it represents an initial exploration that could benefit from a broader sample size and further verification. Additionally, it opens opportunities for future research to consider key concepts such as sustainability, resilience, and digitisation, which align closely with our research focus.

Yang et al. (2021) focus on express parcel flows in China, analysing how COVID-19 has affected these flows through the application of statistical and econometric analyses, such as multiple linear regression models and long-run panel data. Notably, they discover that parcel flow fluctuations are more pronounced between provinces than within them, a finding that aligns with expectations given that production and consumption activities often occur in different provinces.

Cui et al. (2022) examine the Belt and Road Initiative (BRI) using a modified gravity model. They focus on the changes in logistics performance from a spatial perspective that have been triggered by COVID-19, particularly in highway freight. They find that cities have been affected in disparate ways, and the pandemic's impact appears to be regionalised. Accordingly, they propose varying recovery suggestions and policies tailored to different belts within the BRI.

Fang and Guo (2022) utilise high-frequency logistics data to conduct a quantitative examination of China's toll-free highway policy during the COVID-19 pandemic, specifically analysing

how this policy has encouraged road freight. They find that the toll-free highway policy has substantially mitigated the negative effects of the pandemic on freight volumes and prices, thereby stimulating the resumption of production and enhancing inter-regional connections.

In summary, while the literature discussed above presents valuable insights into logistics and transportation during the pandemic, particularly in China, common limitations are apparent. They tend to concentrate on specific areas, either a particular policy, a mode of transportation, or a regional focus, limiting their broader applicability.

Exploring further, research extends into the innovative capabilities that bolster adaptability and recovery during a pandemic. The study by Dovbischuk (2022) uses survey data and structural equation modelling to highlight crucial factors such as new-knowledge distribution, employee training, cross-functional collaboration within firms, and long-term inter-firm relationships, identifying them as essential for resilience. *Particularly, the notion of collaboration resonates with our research, reinforcing the proposition of developing value-based freight coalitions among partners in the freight network*. Gupta et al. (2022) explores the barriers hindering the adoption of innovative digitalisation technology in supply chain logistics during a pandemic. Their study focuses specifically on the context of an emerging economy such as India. Utilising a multi-criteria decision analysis method, the authors pinpoint technological barriers such as a lack of IT infrastructure, economic challenges such as high investment costs, and organisational hurdles, including a lack of support from top management, as the most significant obstacles. While the study offers valuable insights into technological barriers and challenges, the specific focus on expert opinions and digitalisation, within a limited sample size, might influence its applicability to broader contexts.

Additionally, the role of logistics service providers in enhancing supply chain risk management during the pandemic is analysed. Hohenstein (2022) examines the impact of the COVID-19 pandemic on supply chains, focusing on how logistics service providers (LSPs) have leveraged their knowledge to enhance supply chain risk management practices and bolster resilience against future disruptions. This investigation is based on a combination of a comprehensive literature review and case studies involving global LSPs. Hohenstein (2022) identifies eight critical factors, including business continuity planning, flexibility, and digital transformation, that are vital to the adaptive capabilities and resilience of LSPs.

These insights into digital transformation align with our research goals and connect with broader findings in the field of supply chain management, establishing a foundation for the review presented in the next section.

Our research aligns closely with several key themes found in the reviewed studies, especially in areas such as digital transformation and collaboration within the industry. These aspects support our idea of creating value-based freight coalitions and guide our broader examination of the field. Unlike the existing literature that often focuses on specific policies, transportation modes, or regional limitations, our approach takes a broader view. Moreover, our methods differ from the standard quantitative techniques used in previous studies. We employ a hybrid methodology that includes topic modelling, expert interviews for gathering real-world data, and a theory of change framework. This combination enables us to explore the subject in greater depth and context.

2.2 Digitalisation, Resilience, and Sustainability Concepts in Supply Chain Management during Disruptions

Supply chain research, particularly during disruptions, has primarily concentrated on resource allocation, medication distribution, and emergency health responses, as highlighted by Queiroz et al. (2022). Despite these studies, there is a call for deeper insights into epidemic impacts on supply chains, as noted by Ivanov (2020a) and Sarkis et al. (2020). Addressing this, Montoya-Torres et al. (2021) devised a framework to manage disruptions such as global crises, focusing on supply chain agility, alignment, and adaptability. This framework considers factors such as organisational characteristics and logistics operations. It also focuses on sustainability metrics, such as the triple bottom line, tailored to cope with disruptions' severity and duration. Although based on a smaller sample size, their research offers substantial contributions to the field, especially in enhancing supply chain resilience and long-term sustainability.

Queiroz et al. (2022) conduct a structured literature review to identify the research agenda for SCM during the COVID-19 pandemic. They highlight gaps in the literature and categorise these into three clusters: modelling, organisational, and technology. The emerging research agenda emphasised a supply chain focus on sustainability and digitalisation, with the identified gaps mirroring these themes. Pujawan and Bah (2022) further corroborate this focus in their review of literature addressing supply chain disruptions due to the pandemic, confirming that digitalising the supply chain must be one of the top priorities for companies dealing with such disruptions. Moosavi et al. (2022) conduct a literature review concentrating on disruption

mitigation and adaptation in supply chain (SC) strategies. They find resilience and sustainability to be the primary themes.

Our research focus and propositions align well with the gaps and agenda identified by these authors, emphasising the importance of adapting to the modern challenges faced by SCM in times of pandemic.

Beyond digitalisation's role in the supply chain, factors such as the ripple effect and disruption risk control are crucial. Ivanov et al. (2019) explore how digitalisation mitigates supply chain disruption risks, particularly the ripple effect, enhancing demand responsiveness and capacity flexibility. Kumar et al. (2023) investigate the link between digitalisation and supply chain viability, emphasising its importance in risk and resilience management. They suggest that handling disruptions from pandemics, wars and recessions requires a comprehensive digital transformation in supply chain processes. Ivanov and Dolgui (2021) conceptualise a unique digital supply chain twin framework for managing disruptions. This framework integrates both model-based and data-driven approaches, shifting offline decision-making towards advanced supply signal detection and real-time disruption identification. Gebhardt et al. (2022) develop future projections for companies concerning supply chain design alternatives post-pandemic. These projections include measures such as increasing safety stocks, standardising components, developing backup transportation, and enhancing collaboration between supply chain partners, among others. Since these projections are based on mid-term adjustments, there is scope for exploring both immediate and long-term measures.

Our research complements this work by focusing on short- and long-term measures, including buffering and bridging responses, to alleviate the impact of disruptions within and across firms.

Research highlights the significant interplay between supply chain resilience and digital technologies. Ivanov et al. (2021) emphasise the role of supply chain visibility (e.g., Internet of Things (IoT), sensor technology), changing supply chain design (e.g., additive manufacturing), and relationships (e.g., supplier-buyer collaborations) in enhancing supply chain resilience. *Indeed, one of our propositions addressing collaboration between partners in the freight network through digital platforms aligns closely with the authors' insights.* Mishra et al. (2022) analyse pandemic disruptions and the key capabilities for improving supply chain resilience and operational excellence. They note that few studies effectively link disruptions with resilience-enhancing capabilities. *Their insights are consistent with our proposition to use*

digital platforms for cargo booking and monitoring to provide transparency and facilitate enhanced communication among stakeholders.

Continuing the theme of digital integration, Zhou et al. (2023) investigate how supply chain resilience, including restoration and responsiveness, mediates the relationship between digitalisation and performance. They find that digitalisation positively influences performance and suggest that companies adopt digital systems to foster sustainable supply chains. Zhao et al. (2023) examine digitalisation's role in enhancing resilience across the supply chain stages, leading to improved performance. They identify ways in which digitalisation boosts performance, especially in disruptive scenarios, echoing the findings of Zhou et al. (2023). Bechtsis et al. (2022) propose a digitalisation framework focusing on data sharing and monetisation, aimed at enhancing supply chain security and resilience; this presents a promising direction for the cargo transportation industry. Ivanov (2021) investigates how visibility enhances preparedness and resilience in supply chains during pandemics. He notes that, despite growing interest, research on end-to-end visibility in resilient supply chains remains limited or nascent.

Our research addresses this gap, proposing to digitalise cargo operations to enhance real-time end-to-end visibility, rounding off the exploration of the critical importance of digital transformation in today's disruptive supply chain environment.

Our research builds upon prior studies but distinguishes itself in several ways:

(1) Through a comprehensive examination of the cargo transportation and logistics industry during the COVID-19 pandemic, our study offers a broad view rather than concentrating on specific policies, transportation modes, or regional limitations as commonly found in the existing literature.

(2) We belong to a small group of papers that utilise a combination of techniques; in our case, we use topic modelling to identify critical areas and gather empirical data from expert interviews to develop short- and long-term mitigation measures.

(3) Furthermore, to provide practical solutions, we develop a robust supply chain framework based on the Theory of Change and organisational response model to supply chain disruption (Bode et al., 2011), integrating the critical areas and corresponding mitigation measures. This emphasises both short- and long-term strategies to alleviate the impact of disruptions, something that has been an area of opportunity in current research.

3. Topic Modelling

In this section, we utilise a text mining approach called topic modelling to identify critical areas in the cargo transportation and logistics industry. Topic modelling is a machine learning technique that seeks patterns in word usage and assigns semantic meaning to vocabulary, with topics representing groups of frequently occurring words (Greene et al., 2014). We selected this approach due to the ongoing and rapidly evolving impact of COVID-19 on the supply chain. Despite the passage of time since the outbreak of the pandemic, new perspectives and data continue to emerge from various sources, such as news articles, corporate blogs, consultancy reports, research papers, LinkedIn posts, and scientific journals. This abundance of information makes it challenging to identify the most pressing concerns for the cargo transportation and logistics industry in addressing the consequences of COVID-19. Given these circumstances, we believe that topic modelling is a valuable tool for our research.

Topic modelling is a widely used text mining approach for discovering latent variables (topics or themes) in a large collection of datasets and has proven to be particularly effective when applied to text data (Blei, 2012). In our study, we employed the Latent Dirichlet Allocation (LDA) algorithm as a topic modelling approach to identify latent topics or themes within the text corpus of selected cargo logistics publications related to COVID-19 (Hino and Fahey, 2019). LDA was chosen due to its probabilistic nature, simplicity compared to other text mining methods, and ability to generate a weighted list of topics for each document, even with large datasets. This approach has demonstrated insightful results in various studies (Campbell et al., 2015; Negara et al., 2019).

While there are limited applications of topic modelling in the context of COVID-19 and the cargo transportation and logistics industry, several notable examples exist (see Benita, 2021; Bai et al., 2021). We request the readers refer to Appendix III for a review of the LDA algorithm, but for more detailed information, we recommend referring to its extensive implementations in studies analysing public discourse and sentiment during the COVID-19 pandemic (Xue et al., 2020), Industry 4.0 (Janmaijaya et al., 2021), technology road mapping (Zhang et al., 2021), and world trade (Kozlowski et al., 2021).

We now describe the steps involved in the topic modelling approach and explain how we applied this method to identify critical areas in the cargo transportation and logistics industry. To implement LDA and analyse the text documents, we utilised the open-source statistical natural language processing software package called MALLET; this can be accessed at

http://mallet.cs.umass.edu/ (McCallum, 2002). Figure 1 illustrates the steps involved in the implementation process and highlights the tasks associated with each step.

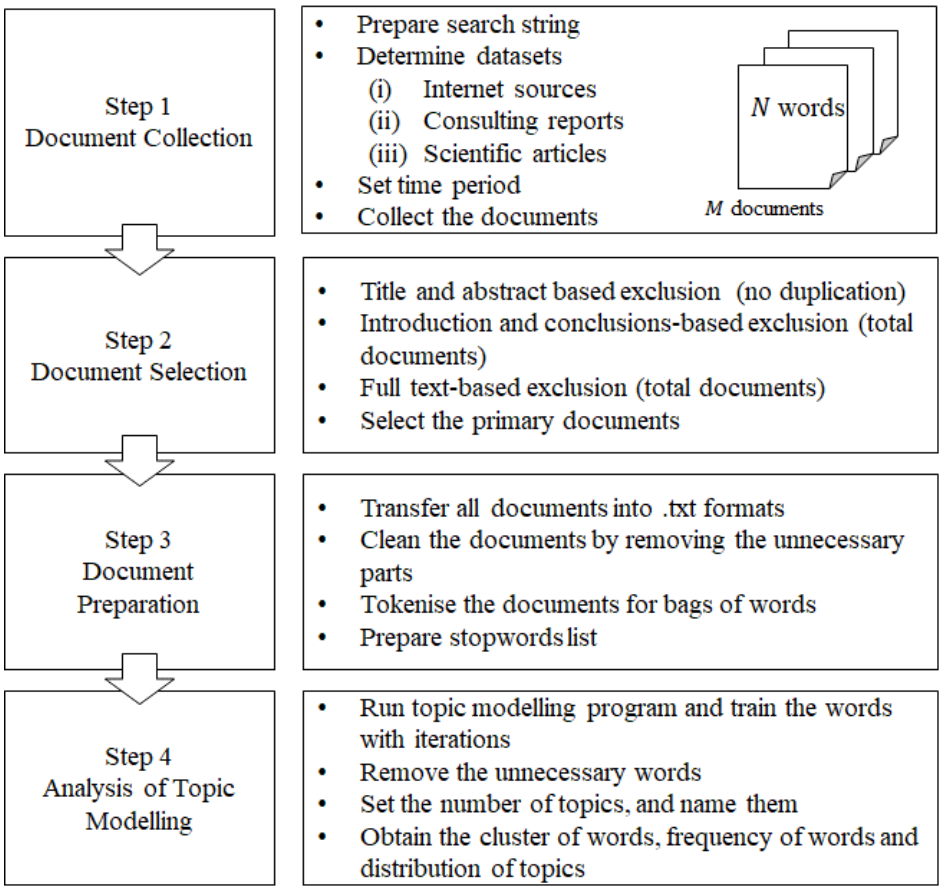

Figure 1 – The steps of topic modelling

3.1 Document Collection

In this step, we identified a set of potential documents for analysis by setting the time period between January and December 2020, which corresponds to the outbreak of the COVID-19 pandemic. To identify the documents, we developed a set of search strings: {"COVID-19" OR "post COVID*" OR "post-COVID*" OR "post corona" OR "corona" OR "coronavirus" OR "covid19" AND "transportation" OR "logistics" OR "supply chain logistics" OR "cargo" OR "supply chain disruptions"}. We searched for potential documents in three different datasets: (i) Internet sources such as news sites, corporate blogs, surveys, forums, and LinkedIn articles; (ii) consulting reports, magazine articles, and white papers from prominent consulting companies; and (iii) academic papers published in scientific databases, including ScienceDirect, Web of Science, Scopus, Taylor & Francis, and GoogleScholar. As a result, we

collected a total of 628 relevant text documents through search engines, and we obtained 30 consulting reports and 18 academic papers.

3.2. Document Selection

We began the process of enhancing data quality by screening the collected text documents. Initially, we sorted the documents based on their contents. Subsequently, each document was manually reviewed, and those that were out of scope, such as documents on medical treatments for COVID-19, were removed. Following this, a full-text screening was conducted, considering the document's title, abstract, introduction, and conclusion, to eliminate duplicates. Upon completion of the screening process, we selected 296 relevant text documents, consisting of 254 from Internet sources (with only 36 presented), 27 from consulting reports, and 15 from academic papers. A total of 78 selected documents are alphabetically listed in Appendix I.

3.3. Document Preparation

In this step, we performed several tasks to prepare the collected text documents for analysis. First, we converted the documents from their original formats (such as pdf and html) into .txt format. Then, we conducted text cleaning by removing extraneous features such as the title page, content page, introductory arguments, executive summary, annexes/appendices, reference list/bibliography, headers and footers, and any other repetitive text that did not contribute to the content. To further refine the text, we compiled a list of stop words; this included common English words such as "is", "and", "or", "was", "where", "the", "a", "in", "of", and "for", as well as other words such as "paper,", "http", "www", "e.g.", "doi", "vol", and "et al.". These stop words were excluded from the analysis. Next, we tokenised the documents by breaking them down into individual words, or tokens. Finally, we created a "bag of words" representation of the text data by counting the frequency of each token in the document. This process resulted in a matrix or vector representation of the documents, where each row represented a unique token and each column represented a different document in the corpus. The value in each cell of the matrix indicated the frequency of that token in the corresponding document.

3.4 Analysis of Topic Modelling

In this step, we began by specifying the number of topics we wanted to discover from the document collection. We used Gibbs sampling (Grün & Hornik, 2011) to determine the optimal number of topics (K). To assess the goodness-of-fit, we utilised perplexity scores, where a lower score indicates a better fit. We performed 6-fold randomised cross-validation with 20 repetitions for 6, 12, 18, 24, and 30 topics to evaluate the perplexity scores. However, we observed that the perplexity scores varied very little among these numbers. Consequently, we

decided to use the fewest number of topics, which was six, as they were simple and easy to understand.

Next, we trained the LDA model with numerous iterations. During the training process, we removed unnecessary words (e.g., “wake”, “walk”, “sun”, “hand”) from the documents and added them to the list of stop words in each iteration. We combined interconnected words (e.g., “supply” and “chain” were linked as a word group represented by “supply+chain”), and we only used one word for those with the same meaning (e.g., “collaboration” and “cooperation” were transformed as “collaboration”). Additionally, through manual data mining, we collected similar words and word groups under the same concept (e.g., “electronic proof”, “e-proof”, and “digital proof” were transformed as “e-proof”).

The LDA algorithm calculates the probability of each word belonging to a specific topic. Once all the iterations were completed, we obtained a cluster of word groups, together with their frequencies based on the assigned topics. Table 1 presents the 20 most likely words in each topic, ranked by frequency; this represents a significant proportion of the overall word distribution.

Table 1- Most likely 20 words in each topic according to challenges of COVID-19

#	**Topic 1**	**Topic 2**	**Topic 3**	**Topic 4**	**Topic 5**	**Topic 6**
1	logistics capacities	order on-time	crisis management	rapid response	manpower planning	automated logistics
2	optimisation	late delivery	occupational safety	contingency planning	safety training	digital technologies
3	agile planning	last-mile	health risks	critical infrastructure	protecting workforce	sensing technologies
4	collaboration	freight cost	safety measures	mergers acquisitions	workplace safety	intelligent transportation
5	demand	lost cargo	lessons learned	public-private partnership	lack of experience	digital supply chain
6	forecasting	efficient routes	no-touch operations	service disruption	team skill	digital monitoring
7	stakeholders	misplaced shipment	smart terminal	working capital	customer services	real-time visibility
8	asset traceability	optimising routes	cargo corridors	cash capital expenditure	communication	consumer sensing
9	network redesign	category strategy	team management	robust risk	employment distribution	demand shaping
10	intermodal services	smart distribution	safe cargo	disruption alerts	workplace hazard of employment	revenue models
11	business models	flexible warehousing	efficiency measures	anticipating future challenges	connected workers	technological innovation

12	automated shipments	fleet management	safety tracking	supply chain dependencies	operations environment	shipping delivery tracking
13	inventory estimation	redesign processes	cross-functional team	on-demand visibility	Staff-sharing	cargo monitoring
14	maintenance	going green	workplace hazard	contract term	manpower utilisation	Big Data analytics
15	order management	forecast strategy	smart ports	zero-error supply	driver shortage	delivery tracking
16	consumer behaviour dynamics	forecast accuracy	digital terminal	stock reliability	informal labour	digital platform
17	fulfilment capability	modifying locations	paper-free operation	risk management	manpower database	paperless supply chain
18	dynamic monitoring	delivery service	safety network facilities	customer think	pooling-in services	e-proof
19	handling	location intelligence	industrial safety rules	tariff structure	workforce scarcity	data security
20	bill of lading	supplier consolidation	visual recognition	smarter alternatives	skeletal staff	IoT adoption

Based on the distribution of words within these six topics, we gained insights into the urgent operational decisions that were made in the cargo transportation and logistics industry in response to the COVID-19 outbreaks. The 20 high-frequency words, or word groups, in each topic, accounted for an average of 23% of the total word distribution. We used these words to interpret and label the topics.

Topic 1 – Operational Inefficiency: The first topic focuses on operational issues such as "logistics capacities", "optimisation", "agile planning", "collaboration", and "forecasting". These terms are likely used in the context of operational inefficiency. The challenges associated with these terms can be categorised as operational inefficiencies; these refer to problems or inefficiencies that occur during the execution of supply chain operations. Inadequate logistics capacity, for example, can result in poor inventory management, insufficient material handling, and longer delivery times, among other issues. Optimisation and agile planning can help in the efficient utilisation of resources and the improvement of process efficiency. Collaboration is essential for effective SCM, as a lack of it can lead to communication breakdowns and delays. Inaccurate demand forecasting can result in excessive stockpiling or insufficient inventory, thereby reducing supply chain efficiency. These issues are interconnected and should be addressed holistically to enhance the supply chain operational efficiency.

Topic 2 – Delivery Performance: The terms "order on-time", "late delivery", "last-mile", "freight cost", and "lost cargo" are likely used in the context of delivery performance. These terms can be seen as delivery performance metrics that have an impact on customer satisfaction and revenue. Late deliveries can lead to revenue loss, increased costs, and harm to the company's reputation, causing disruptions throughout the entire supply chain. Last-mile delivery, which refers to the final and often the most challenging and costly stage of delivering goods to the end customer, significantly affects customer satisfaction, repeat business and revenue generation. Freight cost is another important factor that influences delivery performance, as high freight costs can result in reduced profits, higher prices, and decreased market competitiveness. Lost cargo due to theft, damage, or misplacement during transportation can also have a significant impact on delivery performance, leading to revenue loss, customer complaints, and damage to the company's reputation. Addressing these issues was particularly crucial during the COVID-19 pandemic.

Topic 3 – Safety Issues: The likely terms in this topic include "crisis management", "occupational safety", "health risks", and "safety measures", which are related to safety actions. In a pandemic situation, crisis management is crucial for addressing unexpected circumstances and ensuring the safety of employees. Occupational safety plays a critical role in reducing the risk of COVID-19 transmission and preventing exposure to the virus. Health risks are a major concern in the context of COVID-19, and safety measures, such as the use of personal protective equipment (PPE), practicing social distancing, and regular cleaning and disinfection of facilities, are necessary to minimise the risk of COVID-19 transmission in the supply chain.

Topic 4 – Supply Chain Vulnerability: The terms "rapid response", "contingency planning", "service disruption", "stock reliability", and "risk management" are related to supply chain vulnerability, which refers to the exposure to significant disruptions in the flow of goods and services caused by risks within and outside the supply chain. Rapid response and contingency planning are crucial in mitigating the effects of such disruptions, as they enable the supply chain to quickly adapt and respond to unforeseen circumstances. Service disruption, which refers to any issues that disrupt the normal flow of services, can be indicative of supply chain vulnerability. Stock reliability, which ensures the availability and quality of inventory, is vital to minimising supply chain vulnerability. Risk management involves identifying and managing potential risks, reducing the likelihood of disruptions, and enhancing the overall resilience of the supply chain. By proactively identifying and managing risks, supply chain managers can decrease the probability of disruptions and enhance the overall resilience of the supply chain.

Topic 5 – Manpower Management: The terms "manpower planning", "safety training", "protecting the workforce", "team skill", and "workforce scarcity" are all related to addressing manpower management. Manpower management refers to the process of effectively and efficiently organising, directing, and controlling the human resources (skilled workers) to meet the demand for a particular job or industry. To ensure that critical functions are adequately staffed even during times of manpower scarcity, effective manpower planning is essential. Safety training plays a vital role in protecting the workforce from injuries or preventing the spread of COVID-19, which can lead to a shortage of workers. Safeguarding the workforce's health is crucial to ensuring that employees are available for work. Developing team skills can help mitigate the shortage of manpower by enabling workers to perform a broader range of tasks and maintain productivity levels, even with reduced staffing. Lastly, workforce scarcity can cause significant disruptions in the supply chain, highlighting the importance of effective manpower planning, safety training, workforce protection, and team skill development.

Topic 6 – Digital Infrastructure: The terms "automated logistics", "digital technologies", "real-time visibility", "digital monitoring", and "intelligent transportation" can be broadly interpreted as indicators of digital infrastructure. Digital infrastructure represents the physical assets required to operate technologies such as digital communication, computing, and data storage. The logistics industry can benefit from automation, as it improves productivity and reduces costs. Moreover, logistics and transportation operations can leverage cloud computing, Internet of Things (IoT) sensors, and big data analytics to gain real-time insights, optimise supply chains, and enhance customer service. By utilising digital monitoring tools such as sensors, cameras, and global positioning system (GPS) devices, businesses can obtain real-time information about the location and status of vehicles, goods, and infrastructure, enabling them to identify and address issues proactively. Intelligent transportation systems, such as traffic management systems and vehicle-to-vehicle communication, can reduce travel times, fuel consumption, and emissions, optimising transportation operations. These systems also enhance road safety, minimising the likelihood and severity of accidents and safeguarding employees and assets. Companies that lack these technologies may face a disadvantage. However, adopting these technologies can enhance operational efficiency, reduce costs, and improve safety, making them indispensable for businesses in the digital age.

4. Empirical Data Collection and Analysis

In this section, we examine the impacts of short-term and long-term operational decisions on the cargo transportation and logistics industry in the context of post-COVID-19 preparedness and risk mitigation. To accomplish this, we gathered qualitative data through semi-structured interviews with experts and stakeholders from the cargo transportation and logistics industry. These individuals possess extensive knowledge of transportation and logistics operations and were well-informed about the challenges faced by the sector during the pandemic. The interview questions were formulated based on the areas of concern obtained from the findings of the topic modelling analysis for post-COVID-19 preparedness.

The studies reviewed in Section 2.1 encompass a variety of quantitative techniques, including regression modelling, multi-criteria decision analysis, and structural equation modelling. However, our focus in this section is on studies that utilise interview-based techniques for empirical data collection. For example, Herold et al. (2021) investigated the resilience of logistics service providers (LSPs) during COVID-19 by conducting interviews with LSPs as the primary data source, employing an interpretive research approach. Ashraf et al. (2022) conducted a qualitative study using a combination of questionnaires and interviews to identify paradoxes that have emerged in the context of third-party logistics operations due to COVID-19. Gultekin et al. (2022) employed in-depth interviews and the fuzzy DEMATEL method to identify the uncertainties and risks faced by LSPs during the COVID-19 pandemic, as well as their prominence and cause-effect structure.

The selection of experts was based on the professional network of the first author, ensuring that participating companies were carefully chosen based on their professionalism, knowledge, and experience. Initially, 52 cargo and logistics experts from various European countries were identified and subsequently invited for an interview via email, phone, or messages on LinkedIn/WhatsApp. Out of these, 10 agreed to participate. All the companies involved were medium- to large-sized enterprises from the cargo transportation and logistics industry in five countries (Turkey, Germany, Austria, Italy, and the UK) that encountered challenges during the COVID-19 crisis and had strategic decisions or considerations for future post-COVID-19 business plans. Our sample consisted of ten designated experts from the transportation and logistics sector, with an average work experience of 19 years and holding graduate or postgraduate degrees. Previous research has demonstrated the validity of studies with sample sizes as small as ten or even fewer (Ramanathan et al., 2017; Kurpjuweit et al., 2019; Gultekin

et al., 2022; Hohenstein, 2022). The profiles of the respondents and the corresponding companies involved in the interviews are presented in Table 2.

Table 2 - Basic profile of experts and organisations involved in study

Company	Profile of expert	Experience	Company profile	Company size	Country
A	Business development manager	20 years	International freight & logistics company	Large	Austria
B	Warehouse manager	15 years	Freight forwarder	Large	Italy
C	Port operations manager	22 years	Container terminal and port operators	Large	Turkey
D	Infrastructure and equipment manager	18 years	Transportation company	Large	UK
E	Project manager	20 years	Logistics technology company	Medium	Germany
F	Last-mile operations manager	12 years	Courier delivery company	Medium	Turkey
G	Terminal manager	25 years	Shipping company	Large	Turkey
H	Domestic operations manager	16 years	Transportation company	Large	Germany
I	General manager	24 years	Cargo transportation company	Large	Italy
J	Terminal manager	19 years	International logistics company	Large	Austria

The semi-structured interviews were designed to cover practical aspects related to the challenges posed by COVID-19 in the cargo logistics industry. Each expert was asked a set of 25 questions, addressing various topics such as disruptions experienced during the pandemic, alternative logistics solutions, collaboration with supply chain partners, risk mitigation strategies, employee safety measures, adoption of digital technologies, and future challenges, among others. These questions were developed by consolidating, structuring, and organising the identified words from the search results descriptions, focusing on both short-term and long-term impacts supported by empirical evidence. The questions were categorised and justified according to the subtitles of each topic. Topic 1, focusing on ‘Operational Inefficiency’, included questions 1, 2, 4, 7, and 8. Topic 2, addressing ‘Delivery Performance’, comprised questions 3, 5, and 6. For Topic 3, which examined ‘Safety Issues’, questions 13, 17, 18, 19, and 25 were designated. ‘Supply Chain Vulnerability’ was the focus of Topic 4, covered by questions 10, 11, 12, 14, and 24. Topic 5, concerning ‘Manpower Management’, consisted of

questions 9, 15, and 16. Lastly, Topic 6, which explored 'Digital Infrastructure', encompassed questions 20, 21, 22, and 23. The complete list of interview questions can be found in Appendix II.

The interviews were conducted between 1 September and 1 December 2020. Before the interviews, we emailed the questions to the participants and scheduled the interviews on mutually agreed-upon dates. The interviews were conducted online using video conferencing platforms (Zoom, Microsoft Teams, Google Meet, or Skype). Each online interview lasted approximately one hour, and all interviews were recorded for accuracy. After the interviews were completed, we analysed the findings about short-term and long-term impacts and classified them into six predetermined topics. Table 3 provides an overview of the findings regarding short-term and long-term operational decisions derived from these semi-structured interviews. These findings, categorised into six topics, will be discussed in more detail in the subsequent sections.

Table 3 - The impacts of short-term and long-term operational decisions for post-COVID-19 preparedness

Impact	**Short-term measure**	**Long-term measure**
Operational Inefficiency	• Identifying and securing logistics capacities for operational challenges • Optimisation of production and distribution capacity • Collaborative and responsive planning and fulfilment capabilities (i.e., crossdocking, milk run drop shipping) • Demand forecast accuracy strategy • Communication with supply chain stakeholders • Estimating available inventory (inventory levels, inventory flows)	• Intermodal transportation services • Redesign supply networks and processes • Integrate consumer behaviour dynamics for panic buying • End-to-end asset traceability • New business models and services
Delivery Performance	• Category strategies - re-engineering the distribution of goods • Consolidation of suppliers by geography • Change distribution locations – reallocating fleet	• Flexible warehousing • Green transportation and logistics practices • Real-time location intelligence • Smart distribution centres
Safety Issues	• No-touch (contactless) transportation and tools for health guidelines (i.e., disinfecting deliveries) • Deployment of a cross-functional crisis management team • Occupational safety and health risks at storage and distribution	• Safe cargo corridors • Smart ports and terminals • Lessons learned

Supply Chain Vulnerability	• Contingency planning • Development of robust risk management process • Rapid response • Manage cash and net working capital • Scenario analysis • Respecting contract terms	• Anticipating future challenges • Smarter alternatives • Mergers and acquisitions • Public-private partnership • Rethinking supply chain dependencies • Real-time disruption alerts
Manpower Management	• Protecting workforce in the operations environment • Providing the workforce by collaborating with other companies that temporarily stop working (staff-sharing/ staff exchange)	• Workplace safety training programmes • Hazard communication
Digital Infrastructure	• Automated logistics operations • Adoption IoT and capturing data through sensing technologies (fuel sensors, actuators, GPS devices) • Processing technologies for optimisation	• Establishing digital supply chain platforms • Rapidly and prominently adopting digital technologies • Digital monitoring and tracking • Real-time supply chain visibility • Consumer sensing and demand shaping • Revenue models through service and platform offerings

4.1 Operational Inefficiency

During the pandemic, panic-buying behaviours resulted in significant demand and supply shortages for essential products that are critical for daily life. This phenomenon caused notable disruptions in the supply chain, leading to operational inefficiencies within the transportation and logistics industry. Examples of these inefficiencies include issues such as empty container returns, trailer imbalances, and suboptimal delivery performance. To address these challenges, industry professionals identified both short-term and long-term measures during the interviews, which are summarised in Table 3.

In the short term, companies should focus on optimising their processes for agility and flexibility. One interviewee from Company J suggested, “We would like to optimise our processes through value stream mapping and process mapping to act agile and flexible in the short term”. Another critical short-term strategy involves enhancing collaboration and cooperative capacity sharing (staff and technical capacity) among supply chain partners for both vertical and horizontal collaboration. As one respondent from Company H pointed out, “We shared our staff and resource capacity within group companies when we deemed it necessary. We believe that competition should be outside, not inside, so small companies should definitely merge to share their staff and resource capacity (e.g., sharing transportation and warehouse spaces, loading docks, trucks, forklifts, and other equipment) to tackle short-term operational

inefficiencies. We also considered that surplus truck capacities can be utilised to share with horizontal stakeholders within the truck sharing economy concept to eliminate operational inefficiencies associated with empty containers and empty trips. In addition to this, we believe that developing a collaborative routing model for shared customers with horizontal stakeholders will help maintain operational continuity during disruptions".

Looking towards long-term solutions, industry professionals highlighted the need to invest in automation and advanced technologies. One interview participant from Company J noted, "In order to reduce manual handling in our operations, we want to invest more in automation solutions (cargo robotics, AMRs, AGVs, sensors, IoT) in the long term". Moreover, companies should explore innovative solutions incorporating AI/ML (artificial intelligence and machine learning) and blockchain to enhance traceability and end-to-end visibility, as suggested by one respondent from Company H: "In the long term, our aim is to add more AI/ML solutions and also establish a blockchain-based cloud service infrastructure".

Cargo logistics companies underlined the importance of adapting zero-emission vehicles (electric cargo bikes, commercial electric vehicles, electric trucks and vans) for sustainability, but were also keenly interested in deploying future last-mile delivery services with ground-based autonomous delivery vehicles (droids) and autonomous aerial vehicles (UAVs, drones). Company E noted, "In the future, we are considering using more low- or zero-emission vehicles (e.g., electric light commercial vehicles, electric delivery vans, electric cargo bikes) for sustainable last mile delivery operations. We also closely follow advances in non-traditional delivery vehicles such as aerial autonomous vehicles (e.g., multirotor drones), autonomous unmanned delivery vehicles (e.g., sidewalk robots, road robots, truck platooning) to increase fleet size".

Expanding the network of operations and developing customised last-mile delivery solutions with the integration of digital technologies is another crucial long-term measure. As one respondent from Company J recommended, "In the short term, we want to utilise all our available capacities to avoid any bottlenecks in operations. In the long term, we want to invest in additional capacities via mergers and acquisitions to expand our network of operations. Additionally, we want to offer our customers more customised last-mile delivery solutions powered by digital technologies such as next-day or same-day e-commerce deliveries, omnichannel "pick it up anywhere" deliveries, and *ad hoc* local grocery and restaurant deliveries to meet evolving customer demands and achieve leading position on the market".

As customer demands change, companies must explore new business models (e.g., mobile micro-hubs/warehouses/depots, omnichannel, crowd shipping) and delivery solutions (e.g., click-and-collect delivery options, pick-up and drop-off units, stationary/mobile parcel lockers) to improve operational performance. One participant from Company B emphasised the need to "develop new business models to reduce manual processes in physical operations and automate our operations with new technologies and tools", and added, "In the long term, we want to invest more in click-and-collect, omnichannel solutions, and pick up points such as stationary and mobile parcel lockers and unattended pick-up and drop-off units at various locations to facilitate last-mile delivery operations and improve resilience". Additionally, expanding operation networks is essential, as mentioned by another respondent from Company H: "We are trying to expand our operation network by opening various new branches. Our goal is to establish our own/shared micro-hubs (warehouses) and complete shipment operations without causing inconvenience to our customers". Lastly, adapting to changing demands and technological advancements is crucial for long-term success. One interviewee from Company J noted, "We are considering new business models due to varying demand patterns, dynamic pricing issues, logistics challenges, capacity limitations, and new delivery options, as well as existing and future technology solutions".

Consistent with the work of MacCarthy et al. (2022), our empirical evidence also underscores the effectiveness of supply chain mapping techniques, such as value stream and process mapping, in optimising processes to address short-term operational inefficiencies. In harmony with Hosseinnezhad et al. (2023), our findings support the notion of horizontal collaboration and capacity sharing for staff and resources as strategies to mitigate supply chain disruptions. Echoing Gupta et al. (2022), our study highlights the crucial role of advanced technologies and automation in fostering long-term success, reducing operational inefficiencies, and enhancing supply chain resilience in logistics during the pandemic. Additionally, our empirical evidence reinforces the utility of blockchain-based solutions to optimise container flows and minimise empty runs, aligning with Mhiri et al. (2023). In line with Srinivas and Marathe (2021) and AlKheder et al. (2023), our findings indicate that autonomous delivery vehicles, mobile parcel lockers, and mobile warehousing are effective solutions for addressing last-mile delivery challenges in the pandemic era.

4.2 Delivery Performance

Delivery performance, which has a significant impact on customer satisfaction and revenue, was affected during the pandemic. In the short term, alternative distribution locations and

solutions can be beneficial. One respondent from Company F mentioned: “Since our systems were not designed for high volumes, we had to offer sustainable solutions to deal with high double-digit volume increases, find new city centre locations for last-mile deliveries, as well as overcome and reduce CO_2 emissions and traffic congestion”. Another interviewee from Company J explained that their company utilised alternative options: “We used air transport as an alternative for urgent customers. We also explored collaborative solutions to deliver our customer orders immediately”. Offering consolidated transportation options, such as road and air transport, was suggested by a respondent from Company I: “We offered consolidated road transportation and also air transport as an alternative”.

For long-term measures, flexibility emerged as a key theme. A warehouse manager from Company B discussed adapting their operations: “In order to sustain our business continuity, we flexibly shifted our business operations from just-in-time to just-in-case during the pandemic, and we focused more on customer demands, adjusting all operations according to sudden changing conditions to be more resilient and flexible in responding to our customers. We established closer collaboration with our customers through the proper implementation of just-in-time and just-in-case strategies and the use of digital technologies that provide communication and visibility”. A participant from Company H mentioned: “We updated delivery plans timely according to changes. We kept our operations as flexible as possible to meet customer demand”. Investing in last-mile delivery solutions was also highlighted by a respondent from Company F: “In the long term, we would like to invest more in last-mile delivery solutions to respond to sudden changes immediately and meet the high delivery demand”.

Real-time intelligence is another vital long-term measure. Interviewees from Companies H, I, and A shared their experiences with digital solutions for tracking deliveries. One respondent from Company H noted: “We have our own digital solutions to track the journey of deliveries, including digitalisation, QR codes, digital IDs, RFID, ERP, and NFC”. Another respondent from Company I mentioned: “We track the deliveries within our facilities. We would like to expand this with seamless integrations”. Finally, an interviewee from Company A stated: “We use our own apps to track the movement of cargoes from the point of shipment to the point of delivery. The whole process can be monitored, starting from the delivery of the product until it is delivered to the buyer. All processes, such as vehicle information, driver and courier names, and product location, can be tracked. We utilise digitalisation, QR codes, digital IDs, RFID, ERP, NFC, IoT, and WMS”.

In concordance with Choi et al. (2023), our empirical evidence underscores the importance of shifting from just-in-time to just-in-case strategies, as well as employing advanced technologies, to improve delivery performance during pandemics and to ensure communication and visibility. Similarly, our findings agree with Garola et al. (2023), indicating that digital technologies and enhanced visibility play a pivotal role in ensuring operational continuity.

4.3 Safety Issues

In a pandemic situation, occupational safety is critical for reducing the risk of COVID-19 transmission and preventing exposure to the virus. In the short term, several respondents noted the importance of routine health checks (both onsite and remote), visitor policies, emergency procedures, worker training, and adherence to health regulations. One interviewee from Company A mentioned: “We implemented various emergency processes such as personnel training, in-vehicle hygiene practices, visitor processes, general health checks, and action plans”. Another respondent from Company B stated: “We conducted health checks and onsite and remote PCR tests. We also developed a health plan that we integrated with our operational plans and updated it as needed”. A respondent from Company C emphasised the significance of tracking personal health, stating: “We prioritised healthcare measures such as face masks, antiviral drugs, social distancing, and good hand hygiene in our daily operations. We assigned staff to specific shift cohorts, implemented bubble arrangements to separate staff from different lines and areas during operations, ran alternate lines, and reduced the number of individuals on the lines. We also utilised movable cameras for site control instead of our direct presence. Additionally, we provided personal lockers for coats and personal protective equipment during break times”.

In the long term, the lessons learned from COVID-19 could help companies be prepared for future events. Company D stated: “To raise awareness among our employees and throughout the company, we identify our own experience, as well as the experiences and best practices of others, to prepare lessons learned from the disruptions”. Also, in the long term, innovative ideas leveraging technology could help companies address the challenges posed by the pandemic. A participant from Company A alluded to the possibility of autonomous delivery vehicles as a long-term solution, stating: “I believe certain sectors will be affected by this process. Transportation modes with less physical contact will likely gain more importance, supply chain processes will change, and product delivery stages will be conducted differently. In fact, these changes are not difficulties but necessities”. Another respondent from Company I mentioned: “We aim to proactively collaborate with governments to enhance supply chain resilience. The

goal is to support governments in reshaping processes and infrastructure to ensure policy-makers can fulfil societal missions, such as ensuring a safe supply of food, medicine, and other essential goods".

In line with the findings of Garola et al. (2023), our empirical evidence brings to light valuable lessons learned by practitioners about increasing resilience against future disruptions. Correspondingly, our findings, aligning with those of AlKheder et al. (2023), underscore the utility of autonomous delivery vehicles in addressing issues related to COVID-19.

4.4 Supply Chain Vulnerability

The coronavirus pandemic has exposed vulnerabilities in global supply chains, resulting in shortages, transportation restrictions, and significant disruptions. It is crucial to update short-term and long-term plans to adapt to changes in supply chain priorities, including demand, supply, inventory, logistics, and occupational safety and health risks at storage and distribution facilities. In the short term, contingency planning is of utmost importance. A respondent from Company J noted: "During the crisis, we handled larger volumes than usual. To prevent capacity constraints and bottlenecks, we have developed risk and contingency plans to optimise our available capacity". Risk management is another short-term priority, as mentioned by an interviewee from Company A: "We have implemented a risk mitigation tool for our operations. We evaluated and identified current risks, prioritising them based on probability and impact. We considered risks associated with our network partners and included them in our risk planning. We regularly reviewed risks on a weekly, monthly, and quarterly basis".

Managing cash flow and contractual terms is essential. A respondent from Company I emphasised the importance of addressing business continuity issues and managing contractual risks, stating: "We encountered business continuity problems due to restrictions and lockdowns... We also managed the potential implications for our customer and supply chain contracts to mitigate contractual risks. Additionally, we reviewed financial arrangements and worked with borrowers and lenders to assess potential consequences and implement contingency measures". Another participant, also from Company A, mentioned: "As a domestic service company serving global and Austrian companies and sectors, we often faced situations where payments were delayed beyond the contract terms, typically by 7 to 14 days".

In the long term, companies should focus on anticipating future challenges, investing in automation solutions, and adopting new technologies to minimise manual operations. A respondent from Company B stated: "We aim to invest in automation solutions and new

technologies to reduce manual operations in our processes". Solving truck driver shortages through the introduction of driverless or semi-autonomous trucks was also mentioned by the participant, who said: "One challenge we face is a shortage of truck drivers, which could be addressed if driverless or semi-autonomous trucks enter the market. There are several projects, such as truck platooning, at the EU level to explore these possibilities".

Mergers and acquisitions (M&A) are seen as a long-term strategy. An interviewee from Company I expressed interest in identifying M&A opportunities to build skills and capabilities, enter attractive target markets and trade lines, increase volumes, scale, and create value, stating: "We aim to strategise and identify M&A opportunities to enhance our skills and capabilities, enter attractive target markets and trade lines, increase volumes, scale, and create value". Similarly, another respondent from Company J mentioned a long-term plan to invest in additional capacities through M&A to expand their network of operations and provide more personalised last-mile solutions for customers, stating: "In the long term, we aim to invest in additional capacities through M&A to expand our network of operations. Additionally, we want to offer more personalised last-mile solutions for our customers".

Reflecting the findings of Alexander et al. (2022), our empirical evidence underscores the importance of monitoring and managing risk and vulnerabilities at technological, financial, strategic, and operational levels. The evidence also highlights the significance of digital technologies and the necessity of end-to-end visibility and integrated planning for successful business continuity. Additionally, our evidence suggests that M&As can be effective in alleviating supply chain vulnerability, fostering collaboration, and maintaining resilience.

4.5 Manpower Management

Effective manpower management is important during pandemics, as companies need to prioritise safeguarding the health of their workforce to ensure their availability for work. In the short term, several companies have taken significant measures to protect their workforce and maintain health and safety. For example, a respondent from Company C mentioned: "We consistently assigned staff to the same shift cohort, created staff bubbles across different lines and areas, implemented alternate lines, and reduced the number of individuals on lines". Another participant from Company F stated: "We arranged hotel stays for the workforce involved in delivery operations". Similarly, an interviewee from Company H emphasised the importance of cleanliness, stating: "We ensured cleanliness in all our operational areas to the best of our abilities".

Short-term staff-sharing emerged as a strategy with varying opinions. A respondent from Company F found it helpful, stating: "We shared our staff capacity with other organisations in shared warehouse facilities during the pandemic to sustain operational continuity". However, another participant from Company J considered it risky and sensitive, stating: "We do not consider staff-sharing; we find it very risky and sensitive". In some cases, it was not even possible, as noted by a participant from Company E: "No, it is not possible in our case".

In the long term, many participants agreed on the importance of adequate training. An interviewee from Company J mentioned: "We have made efforts to keep our workforce unaffected by the impact of COVID-19. We have invested in educating and training our workforce to make them aware of the COVID-19 situation". This emphasis on employee training and education helps ensure that the workforce remains healthy and available to tackle the challenges that arise in the logistics industry during pandemics.

Echoing the insights of Garola et al. (2023), our empirical evidence identifies the pivotal role of employees and knowledge as crucial facilitators of operational continuity. In alignment with the findings of Hosseinnezhad et al. (2023), our evidence also emphasises the effectiveness of rotational arrangements for staff-sharing in the same physical space among horizontal stakeholders to enhance resilience. However, it is noted that staff-sharing remains a contentious practice for many organisations.

4.6 Digital Infrastructure

Disruptive technologies and business innovations are reshaping the cargo transportation and logistics industry, highlighting the importance of agility, digital capabilities, and security. The COVID-19 crisis has emphasised the need for digital solutions, products, and services. For example, a respondent from Company B mentioned: "We are developing new business models to minimise manual processes in physical operations and automate our operations with new technologies and tools".

In the short term, many companies recognise the significance of capturing data through sensing technologies and IoT solutions. A participant from Company C stated: "We aim to incorporate more IoT embedded solutions to predict any disruptions in our operations in advance". Similarly, another participant from Company E expressed their interest in utilising IoT-based solutions, such as demand sensing and short-term response planning technologies, in their logistics chains. Interviewees from Company H and Company G also stressed the importance of implementing data sensors, with Company H mentioning: "In the short term, we are applying

more IoT data sensor-oriented solutions in our systems to track and trace our operations", and Company G noted: "embedded sensors, actuators, and other devices".

In the long term, the focus shifts towards consumer sensing and demand shaping. A respondent from Company A noted: "We utilise IoT-based data sensor solutions for demand sensing". Likewise, another participant from Company H expressed the desire to employ technology-based solutions, they said: "In the long term, our goal is to add more AI/ML solutions and establish a blockchain-based cloud service infrastructure".

Some companies are already advanced in adopting and updating their digital technology capabilities, including AI, BDA, AR/VR, robotics, 5G, blockchain, and pick-by-X (pick-by-voice/mobile/vision/point), while ensuring seamless integration of information systems such as ERP, TMS, WMS, LM, and Control Tower. For example, a respondent from Company B stated: "Yes, we have our own digital solution that incorporates cutting-edge technologies such as AI, ML, DL, IoT, AR, VR". Another respondent from Company H mentioned: "We have cloud-based digital solutions, and we also adapt Industry 4.0 technologies to enhance the efficiency and effectiveness of our operations". Conversely, some respondents expressed their intention to invest in digital technologies, stating: "We want to invest in more AI, ML, DL, and blockchain applications in Industry 4.0" [Company I], and "We currently use some solutions such as edge computing and business analytics. We plan to invest more in CPS, AI, ML, DL, and blockchain for future Industry 4.0 applications" [Company J].

Digital monitoring and tracking are also important long-term considerations for the industry. A respondent from Company A mentioned: "We use our own apps to track the movement of cargoes from the point of shipment to the point of delivery. The entire process can be monitored, starting from the delivery of the product until it reaches the buyer. We can track vehicle information, driver and courier names, and the location of the product". Another respondent from Company C highlighted their use of an online vessel and load tracking system to monitor deliveries in real-time. However, companies like Company I currently track deliveries only within their facilities and aim to expand this with seamless integrations. Overall, addressing the digital infrastructure in the cargo logistics industry is crucial for enhancing efficiency and resilience during crises such as the COVID-19 pandemic.

Consistent with the findings of Gupta et al. (2022), our empirical evidence underscores the critical importance of digital infrastructure and capabilities in addressing challenges during the

COVID-19 pandemic, thereby ensuring resilience and sustainability. Through the leveraging of seamless integration, digitalisation, emerging technologies, and advanced software, increasing real-time visibility into the supply chain enables organisations to more effectively plan, schedule, and monitor their logistics processes at every point. This enhanced oversight facilitates better adjustment and rescheduling of their operations in the face of disruptions.

5. Robust Supply Chain Framework

In this section, we utilise Lewin's three-stage model of change (Lewin, 1958) in conjunction with the organisational response model to supply chain disruption (Bode et al., 2011), aiming to develop a framework for robust and resilient supply chains. The Theory of Change (ToC) is a well-known evaluation and planning approach used for international initiatives or programmes, especially when dealing with complex interventions. It aims to understand the underlying assumptions, change processes, beliefs, and contributions made by an intervention to determine how and why it works (Arensman et al., 2018). The ToC serves as a management tool or formal planning methodology to analyse the functioning of development interventions, providing a roadmap from the current state to the desired future state (Stein and Valters, 2012).

Lewin's Theory of Change has been widely used in the fields of organisational development, social work, and public health. It is often preferred over other theories, such as Prochaska and DiClemente's Change Theory and Social Cognitive Theory, due to its simplicity and emphasis on motivation for change. Its integration into organisational culture and popularity among business consultants also contribute to its preference (Zand and Sorensen, 1975). In the context of supply chains, the ToC has been applied in areas such as humanitarian logistics and healthcare (Beuchelt et al., 2022; Anjomshoae et al., 2022). For example, practitioners use this tool to assess changes in scenarios such as regional disease outbreaks or to improve capacity in emerging economies' supply chains. Similarly, the United States Agency for International Development (USAID) documented the implementation of training programmes designed to improve the skills and work performance of supply chain managers. However, it is important to note that there has been limited research in other fields utilising the ToC. An early study by Zand and Sorensen (1975) explored the effective use of the ToC in management science, but there is a significant research gap regarding its application in understanding the impact of the COVID-19 pandemic on the cargo transportation and logistics sectors.

We also drew insights from the model proposed by Bode et al. (2011) concerning organisational responses to supply chain disruptions. Based on their framework, we examined two significant

organisational responses triggered by disruptions—buffering and bridging. These responses are linked to stability motives characterised by trust and dependence. They also involve interpretive postures, incorporating intrafirm characteristics such as supply chain disruption orientation and prior experience, all viewed through the lens of digital technology. This conceptualisation was integrated into the ToC to formulate a robust supply chain disruption framework. Organisational responses to supply chain disruptions primarily leverage resource dependence and information exchange theories to comprehend how stability can be achieved through buffering and bridging response strategies. The buffering response involves endeavouring to establish stability by implementing safety measures that shield a firm from disturbances through collaborative relationships with partners. Similarly, bridging actions pertain to efforts aimed at managing uncertainty through boundary spanning and boundary shifting actions with external partners.

Cargo transport and logistics companies exchange information and share their experiences during the preparedness process. One key lesson learned from combatting COVID-19 challenges is the importance of being prepared and proactive rather than reactive. Therefore, companies need to act swiftly, embrace change openly, and continuously develop strategies to effectively address challenges and generate short-term and long-term value for resilient supply chains.

In this context, both the Theory of Change (Lewin, 1958) and organisational response model to supply chain disruption (Bode et al., 2011) are applied to discuss interventions for achieving robust supply chains and improved outcomes. The theory of change explains how activities undertaken by interventions such as projects, programmes, or policies lead to desired results. Lewin's three-stage model of change focuses on the driving forces that facilitate or hinder change and emphasises the agreement, collaboration, and support of relevant leadership for successful implementation. The three stages include unfreezing (initiating the desired change) or motivations and interpretive mechanisms by intra- and inter-firm characteristics influencing supply chain disruption, changing (implementing the desired change), or buffering or bridging responses, and refreezing (solidifying the desired change to achieve the required outcomes). Applying this model to operational decisions for post-COVID-19 preparedness in the cargo transportation and logistics industry involves addressing various facets, including operational inefficiency, delivery performance, supply chain vulnerability, safety concerns, manpower management shortages, and the digital infrastructure gap. Figure 2 illustrates the application of Lewin's and the organisational response model to disruptions.

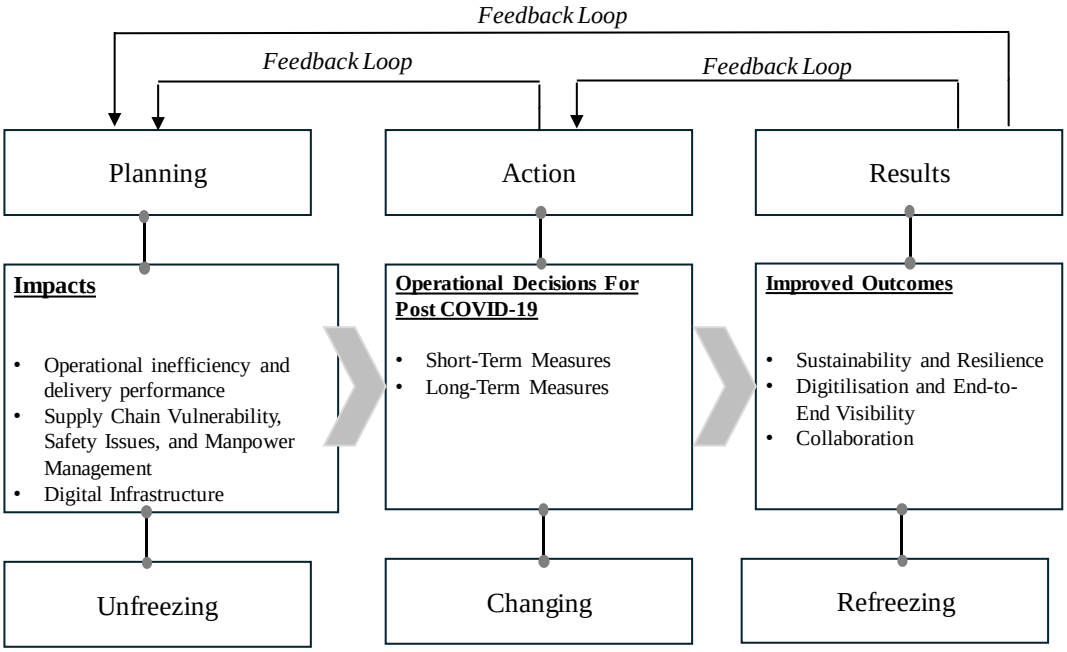

Figure 2 - Robust resilient supply chain disruption model

The impacts related to planning encompass motivation and interpretive mechanisms within and across firms during disruptions. Similarly, the action corresponds to a trade-off between buffering and bridging responses in the short-term and long-term, aiming to enhance outcomes related to sustainability and resilience, digitalisation, end-to-end visibility, and collaboration.

The issues discussed under efficiency, vulnerability, and digital infrastructure reveal the accumulation of knowledge corresponding to supply chain disruption orientation and prior experience within the firm. Establishing trust and dependence with external partners over time is crucial. In terms of action, we have included the trade-off between two response strategies—buffering and bridging—in the short and long term. The discussion in Sections 4.1 to 4.6 highlights that, in the short term, firms and previous studies recommend engaging in buffering initiatives to gain stability with minimal effort in engaging in bridging responses. Conversely, in the long term, cargo firms are advised to be proactive, developing digital capabilities to build trust and manage dependence with external partners, thereby avoiding impacts during disruptions. Furthermore, the stages of planning, action, and results are interconnected through a feedback loop, forming a close-loop iterative process that continuously refines and enhances each stage, as shown in Figure 2. Overall, these initiatives are expected to potentially yield robust processes and better outcomes, as illustrated in the results category in Figure 2. In summary, the cargo transportation and logistics industry must embrace inclusivity, digitisation,

transparency, resilience, and sustainability in the aftermath of COVID-19 to effectively navigate future crisis situations.

5.1 Sustainability and Resilience

The COVID-19 pandemic, in the current global context, has highlighted the need for sustainability and resilience in the freight transport system. This is driven by environmental concerns, including the need to reduce CO_2 emissions and disruptions caused by the pandemic. As a response, cargo companies are exploring carbon-neutral or low-emission transport solutions, such as electric cargo bikes (e-cargo bikes) and cargo tricycles for last-mile deliveries in city logistics operations. These solutions are intended to minimise costs and improve delivery speed, potentially enhancing customer service. Moreover, sustainability policies, for example, equal and green growth based on innovation, are becoming crucial. These policies aim to address the disruptions caused by unforeseen events such as the pandemic (Klein et al., 2022). The pandemic has also accelerated the trend towards outsourcing logistics services (Perkumienė et al., 2021), indicating a greater need for resilience and efficiency in global value chains for transport and logistics operations within and between countries (Twinn et al., 2020).

Simultaneously, industry feedback provides practical strategies to achieve this resilience, which aligns with these scholarly insights. The industry suggests short-term strategies, such as adopting risk and contingency plans, to manage current uncertainties and optimise available capacities. Longer-term strategies recommended by industry insiders, such as expanding operational networks, diversifying markets, and building additional capacities, are similarly noted in the literature as important for mitigating the impact of disruptions such as the pandemic (Desai, 2020).

Based on these findings from both literature and qualitative industry data, we propose:

Proposition 1: Developing a focused freight transport strategy for disruption preparedness that addresses short-term and long-term response trade-offs is essential for achieving sustainability and resilience outcomes.

The proposed strategy aligns the scholarly emphasis on sustainability and resilience with the practical risk management strategies identified in industry feedback. Therefore, this strategy provides a broader approach to managing both current and future disruptions, underpinning a more sustainable and resilient freight transport system.

5.2 Digitalisation and End-to-End Visibility

The COVID-19 pandemic has emphasised the urgency for flexibility, automation, and end-to-end visibility in cargo transport and logistics networks. Digital technologies and Industry 4.0 innovations (AI/ML, cloud computing, big data analytics, 5G, blockchain), alongside drones and robotics, provide practical tools for this transformation, as evidenced in both the literature and industry feedback.

From a literature standpoint, Magableh (2021) underscores the role of digitalisation and end-to-end visibility in managing future crises, suggesting that they can enhance organisational efficiency and risk management capabilities post-crisis. Similarly, Klein et al. (2022) identify the effective adoption of innovations as a significant accelerator in this respect. The transportation and logistics industries show growing interest in utilising data and information sharing tools (Twinn et al., 2020). These technologies facilitate real-time monitoring of workforce health and psychology (Ansari et al., 2023), and enable more efficient and secure electronic and mobile payment solutions (Perkumienė et al., 2021). Magableh (2021) and Desai (2020) further stress the importance of achieving end-to-end visibility across the entire network. They view this as a long-term strategy for enabling stakeholders to respond to rapid changes, streamline processes, and reduce costs.

The feedback from the industry corroborates these findings, indicating a strong interest in investing in automation and advanced technologies such as robotics, sensors, and IoT. The feedback highlights the need for technologies that reduce manual processes and enhance real-time intelligence, including blockchain-based cloud service infrastructure and AI/ML solutions. This digital transition aligns with the changing demands and technological advancements necessary for long-term success. Innovative ideas leveraging technology, such as creating apps for real-time tracking of deliveries and less physical contact in transportation modes, further underline the critical role of digital technology in future-proofing cargo operations.

In light of this synthesis of literature and industry feedback, we formulate the following:

Proposition 2: The adoption of digital technology and the development of new business models, including emerging technologies, will enhance the digitalisation of cargo operations and improve real-time end-to-end visibility for tracking cargoes.

This proposition integrates the theoretical insights from the literature with practical strategies from industry feedback, advocating for a comprehensive approach that leverages digital technologies and business model innovation for a more sustainable way to improve end-to-end visibility.

5.3 Collaboration

The COVID-19 pandemic has propelled cargo and logistics companies to intensify their collaborative efforts across the freight network. They form coalitions to facilitate data sharing, the pooling of physical logistics capacities such as transport modes and warehousing, as well as joint initiatives such as staff-sharing, exchange programmes, and contingency planning. The effectiveness of these coalitions can be further enhanced by the use of digital platforms and tools, such as software-as-a-service (SaaS) applications. These tools offer advanced planning capabilities and facilitate transparency, visibility, and communication within the supply chain. Literature on the subject, including studies by Rinaldi and Bottani (2023), Klein et al. (2022), and Perkumienė et al. (2021), support these findings, underscoring the necessity of both vertical and horizontal collaboration for robust supply chain development in the post-COVID-19 era. Magableh (2021) further supports this sentiment, drawing attention to the importance of inter-stakeholder collaboration in mitigating supply disruptions and enhancing service performance.

Industry feedback supports these findings, suggesting enhanced collaboration and capacity sharing as key strategies for improving operational efficiency. Some companies have even begun sharing staff capacity and proactively collaborating with governments to ensure supply chain resilience. In practice, they have found that such cooperative solutions, including collaborations with air carriers, can significantly improve delivery performance and contribute to addressing safety concerns.

Informed by the converging insights from literature and industry feedback, we propose:

Proposition 3: Building value-based freight coalitions among partners in the freight network through digital platforms will enhance collaboration and help address potential operational challenges.

This proposition advocates for leveraging digital technologies to foster collaboration within freight networks. Through this collaborative approach, we anticipate that it could lead to a more

adaptable and resilient freight transport system, potentially better equipped to handle future disruptions.

6. Conclusions, Limitations, and Future Research

COVID-19 has presented significant challenges for companies in the cargo transport and logistics industry, resulting in income losses, widespread disruptions, and market shocks due to ongoing uncertainty. Simultaneously, the pandemic has created new issues such as increased demand for bulky goods deliveries, continued growth of e-commerce, greater community health and safety concerns, and a need for transparency and fast delivery. These factors have put strain on logistics companies, requiring them to adapt new business models and processes. While there is no universal strategy to address the impacts of the COVID-19 pandemic, it is critical for companies to proactively prepare for and prevent issues. This can be achieved through sustainability and resilience measures, digitalisation, end-to-end visibility, and collaboration. This research combines topic modelling and empirical evidence to examine the effects of the COVID-19 crisis on the cargo transportation and logistics industry, as well as to identify short-term and long-term operational decisions for post-COVID-19 preparedness.

Theoretical Contribution:

The study enhances knowledge by proposing a contextualised framework through an investigation of the challenges faced by the cargo transportation and logistics industry during the COVID-19 pandemic. This involves the classification of key short-term and long-term operational decisions to address disruptions in the future. Additionally, this study aligns with Lewin's change model and organisational response model to disruptions. It puts forward three new propositions: (i) pertaining to freight transportation strategy; (ii) adopting digital technology and business models; and (iii) establishing coalitions to achieve articulated goals. These propositions have the potential to lead to improved outcomes in building robust supply chains.

Managerial Contribution:

From a managerial standpoint, this research provides companies in the cargo transportation and logistics sector with a deeper comprehension of the challenges encountered during the COVID-19 crisis. It offers insights into short-term and long-term operational measures for post-COVID-19 preparedness. By doing so, it aims to enable companies to construct resilient supply chains

and effectively manage disruptions stemming from future outbreaks. Achieving this involves crafting dedicated freight transport strategies, embracing suitable technological solutions, and forming value-based freight coalitions.

Limitations and future research

The study employed a hybrid approach to construct a framework and develop propositions. However, our focus was primarily on the broader challenges related to disruptions in cargo transportation. We did not examine micro-level issues within cargo firms and warehouses. Future research could refine the framework to include individual stakeholder levels within the cargo transportation supply chain. Furthermore, collecting additional empirical data would be essential to validate the propositions. Viability is defined as the ability of a supply chain (SC) to maintain itself and survive in a changing environment. This involves redesigning structures and replanning performance to achieve long-term impacts. According to Ivanov (2021), it includes three perspectives: agility, resilience, and sustainability. In our research, we consider resilience and sustainability concepts to overcome the disruption; in the future, we could incorporate agility ideas in the context of cargo transportation and make it viable.

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Appendix I: The selected documents for topic modelling

#	Reference	Type	#	Reference	Type
1	Abrahamsson (2020)	(i)	40	Kilpatrick & Barter (2020)	(ii)
2	Migne et al. (2020)	(ii)	41	Kliuyeva (2020)	(i)
3	Alicke et al. (2020)	(ii)	42	Thomas et al. (2020)	(i)
4	Arull (2020)	(i)	43	Kumar (2020)	(i)
5	Atkins Acuity (2020)	(ii)	44	Lasater (2020)	(i)
6	Avetta (2020)	(ii)	45	LeanCor (2020)	(ii)
7	Becdach et al. (2020)	(ii)	46	de Sousa Jabbour et al. (2020)	(iii)
8	BHS (2020)	(ii)	47	Mahnken (2020)	(i)
9	Bombelli (2020)	(iii)	48	McKinnon (2020)	(ii)
10	Cerasis (2020)	(ii)	49	McKinsey (2020)	(ii)
11	Choi (2020)	(iii)	50	Mullins (2020)	(i)
12	Claconnect (2020)	(ii)	51	Narula et al. (2020)	(iii)
13	Cognizant (2020)	(i)	52	Nikolopoulos et al. (2021)	(iii)
14	Condon et al. (2020)	(ii)	53	Palmer (2020)	(i)
15	Cordon & Buatois (2020)	(i)	54	Paul& Chowdhury (2021)	(iii)
16	Davies &Robson (2020)	(ii)	55	Pitel (2020)	(i)
17	De Smet et al. (2020)	(ii)	56	Queiroz et al. (2020)	(iii)
18	del Rio-Chanona et al. (2020)	(iii)	57	Reimer (2020)	(i)
19	Desai (2020)	(ii)	58	Van Hoek (2020)	(iii)
20	Doherty & Botwright (2020)	(ii)	59	RGS (2020)	(ii)
21	Dollimore & Cooper (2020)	(ii)	60	Rodriguez & O'Toole Morgan (2020)	(i)
22	ECG (2020)	(ii)	61	Rymell (2020)	(ii)
23	Ecomobility (2020)	(i)	62	Saenz (2020)	(i)
24	Ertico (2020)	(i)	63	Saunders (2020)	(i)
25	Fehrenbacher (2020)	(i)	64	Seifert & Markoff (2020)	(i)
26	Fox et al. (2020)	(ii)	65	Sengupta (2020)	(i)
27	Gardner (2020)	(i)	66	Sharma (2020)	(i)
28	GRP (2020)	(i)	67	Singh et al. (2020)	(iii)
29	Gunessee & Subramanian (2020)	(iii)	68	Skou (2020)	(i)
30	Hannon et al. (2020)	(i)	69	Speer (2020)	(i)
31	Twinn et al. (2020)	(i)	70	Straube & Nitsche (2020)	(i)
32	Ivanov (2020a)	(iii)	71	Twilio (2020)	(ii)
33	Ivanov (2020b)	(iii)	72	WEF (2020)	(ii)
34	Javaid et al. (2020)	(iii)	73	Whelan (2020)	(i)
35	Kalla et al. (2020)	(iii)	74	Wilding (2020)	(i)
36	Kane & Tomer (2020)	(i)	75	Wilding et al. (2020)	(ii)
37	Keegan (2020)	(ii)	76	Williams (2020)	(i)
38	Khan (2020)	(i)	77	Wilson (2020)	(i)
39	Khandelwal (2020)	(i)	78	Xiao & Fan (2020)	(ii)

Types of documents: (i) Internet sources, (ii) consulting reports, (iii) academic papers
Note that because of large number of documents, social media sources are not included in the list.

Appendix II: Semi-structured questionnaire to capture how and why change is needed to become resilient

Questionnaire

Demographic data

1. Respondent position:

2. Total years of experience in cargo logistics:

3. The size of the company: small/medium/large

4. The services: international/national

5. Location of company:

6. Educational background:

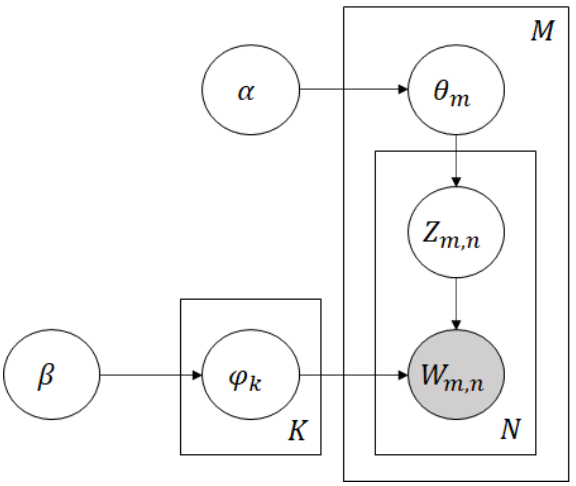
Semi structured interview questions

1) What kind of disruptions did you encounter in your cargo operations due to the pandemic? How did the plans change?
2) What kind of transports have your company suffered from the pandemic?
3) What kind of alternative logistics solutions did you company offer during the pandemic?
4) Do you consider new business models and services? If yes, what?
5) Are you open to collaborate with your supply chain partners (vertical collaboration) and your competitors (horizontal collaboration)? In which ways did (do) you collaborate with other freight operators during the pandemic?
6) What measures did you take to improve the delivery performance of your company?
7) How did you overcome/survive financial difficulties during pandemic?
8) Do you have any financial plan to stay on the safe side for post COVID-19?
9) How has your workforce been affected by COVID-19? (i.e., managing cash) What kind of measures did you take during lockdowns?
10) What kind of business continuity plan did you need?
11) How did your company develop risk and contingency plan for post COVID-19?
12) Do you have any risk mitigation tool for your business operations?
13) Are you aware of the threats and legislation that affect your organisation due to pandemic?
14) What is your operational plan as a logistics company for overcoming the impact of pandemic? Short-term tactical and long-term strategical?
15) How do you protect your workers at your workplace against coronavirus? Do you have any employee healthcare plan?
16) Do you consider to share or exchange the staff to fulfil the capacity in case of disruptions?
17) What did your company do to comply with or proactively arrange for a safe continuation of cargo operations?
18) How do you consider the safety issues for your operations?
19) What kind of transport is currently the safest way to deliver shipments?
20) What is your short-term and long-term plan for digitalisation?

21) Do you use any digital solution (s) based on cutting-edge technologies (i.e. industry 4.0, AI, ML, blockchain) to adopt your operations?
22) Are you capable to track the whole journey of deliveries?
23) Did you check your IT network and cyber security measure (cyber-threats) and rules?
24) How do you anticipate future challenges for post COVID-19?
25) Lesson learned from other business/companies- what will you do differently after the corona pandemic for your cargo transport operations?

Appendix III Topic modelling methodology

The primary objective of topic modelling is to identify hidden topics or themes within a text corpus, which represents a large group of text documents. Each document can be seen as a mixture or proportion of different topics, and each topic is characterised by a distribution of words that are more likely to be associated with that topic. For example, when applying the LDA algorithm to a news article about the latest trends in coffee shops, it might uncover "coffee" as one of the hidden topics. The algorithm would then identify a set of words that frequently occur with this topic, such as "espresso", "cappuccino", "latte", "coffee beans", "barista", and "brewing". However, since a single document may contain multiple topics (e.g., "tea" could be another topic in the same news article), and the same set of words can be associated with multiple topics, the weights assigned to these words depend on their frequency within the text data and their association with the specific topic. LDA analyses input documents using a Bayesian estimation framework and produces two outputs: (i) the probability distribution of topics within the input documents and (ii) the probability distribution of words within a topic (Han et al., 2016).



Parameters of the model:
K is the number of topics, $k \in [1, K]$
N is the number of words in the document, $n \in [1, N_m]$
M is the number of documents to analyse, $m \in [1, M]$
α is is the parameter of the distribution of topics per document
β is the parameter of the distribution of words per topic
φ_k is the word distribution for topic k
θ_m is the topic distribution for document m
$Z_{m,n}$ is the topic assignment for $W_{m,n}$
$W_{m,n}$ is the n-th word in the m-th document
θ and φ are Dirichlet distributions, Z and W are multinomial.

A graphical model of latent Dirichlet allocation (Blei, 2012)

The above figure presents a graphical model of the LDA algorithm, accompanied by the model parameters listed on the right. In the figure, each node represents a random variable, with shaded nodes indicating *observed* variables and unshaded nodes representing *hidden* variables. Rectangles indicate replication, *N* plate denotes the collection of words within documents, and the *M* plate denotes the collection of documents within the collection. N_m is the number of words in m^{th} document, while *K* is the number of topics which is an input parameter. $W_{m,n}$ represents the *observed* variable of the n^{th} word in m^{th} document. The *hidden* variables include (i) θ_m, the

topic proportions for the m^{th} document, (ii) $Z_{m,n}$, the topic assignment for the n^{th} word in the m^{th} document, and (iii) φ_k, the word distribution over all words for topic *k*.

The key computational task in LDA is to infer the hidden topic structure from the input documents by computing the posterior distribution, which represents the conditional probability of the hidden variables given the input documents. To obtain this posterior distribution, we need to compute the joint distribution of all the random variables, including both hidden and observed variables, as described earlier. This joint distribution corresponds to the generative process of LDA, which can be expressed mathematically as follows (Blei, 2012):

$$p(\alpha,\beta) = \prod_{k=1}^{K} p(\beta).\prod_{m=1}^{M} p(\alpha).\left(\prod_{n=1}^{N} p(\theta_m).p(W_{m,n}|\varphi_{1:K},Z_{m,n})\right) \quad (1)$$