Disruptions in Supply Chain Transportation: A literature review

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***Abstract*— Efficient and well-organised transportation is crucial to the success of any supply chain operation, but disruptions can occur in competitive and globalised environments, leading to potential damage and interruptions. A thorough literature review on supply chain transportation research is conducted to address these disruptions from a transportation perspective. The objective is to present recent research on various aspects of the transportation problems, address the gap considering disruptions and propose a framework that outlines the factors that may cause transportation disruptions, their relationships, the types of impacts they have, and how they depend on one another.**

***Keywords*—Supply Chain, Disruption, Planning and Scheduling, Transportation.**

I. INTRODUCTION

Efficient supply chain and logistics operations play a fundamental role in the success of businesses today. With the rise of globalisation and the expansion of markets, supply chains have become more complex, and transportation has emerged as a critical component in managing these complex systems (Chandra et al., 2018). Hence, transportation became an essential component of the supply chain, which enables the movement of goods from one location to another. Transportation costs account for a significant portion of the total logistics cost of the supply chain (Gligor and Holcomb 2012), and effective transportation management can provide a competitive advantage to firms by enhancing their customer service, reducing costs, and improving operational efficiency. However, transportation disruptions can have severe consequences on the performance of supply chains. Transportation disruptions can have severe consequences on the performance of supply chains. Various factors, such as natural disasters, political instability, labour strikes, accidents, and pandemics, can cause transportation disruptions. These disruptions can result in delays, increased costs, lost sales, and damage to firms' reputations. For instance, the COVID-19 pandemic disrupted the global supply chains, causing shortages of essential goods, shipment delays, and transportation costs (Dolgui and Ivanov, 2020; Mahmood et al, 2022).

Transportation management involves various activities such as routing, scheduling, carrier selection, and mode selection. Hence, efficient transportation management is critical for the smooth functioning of the supply chain. Therefore, identifying the disruption factors in supply chain transportation problems is critical for developing effective mitigation strategies. Identifying disruption factors can enable firms to anticipate and respond to disruptions in transportation effectively. Various approaches have been proposed for identifying the disruption factors in supply chain transportation problems, such as risk management, resilience, and contingency planning (Sheffi 2018). These approaches can help firms to assess their vulnerabilities to disruptions and develop strategies to minimise the impact of disruptions on their supply chains. This paper proposes a thorough literature review on the supply chain transportation problems and identifies the consideration of disruptions. The aim is to provide a research gap in the attention of those problems and provide a framework to capture the disruption factors to be considered in the identified gap.

This paper is structured as follows: Section II presents the literature review, categorising the transportation problems, identification of disruption, and the research gap. Section III proposes the framework for identifying the disruption factors. Section IV provides discussions and recommendations of the findings. Finally, Section V is the conclusion of this paper.

II. LITERATURE REVIEW

A. Literature Collection

Supply chain management has become an integral part of business operations, and with the advent of globalisation and e-commerce, the complexity of supply chains has increased. The literature and research on supply chain problems and transportation issues have increased significantly over the past few decades. Researchers have explored various aspects of supply chain management, such as demand forecasting, inventory management, supplier selection, and logistics management. Moreover, transportation problems have also received attention in the literature, including route optimisation, freight management, and carrier selection. Therefore, to identify disruptions in the supply chain transportation problem, this literature review is conducted on 30 articles after excluding 17 articles for irrelevancy. The selection of those articles was processed as follows:

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1) Develop Research Strategy, identifying and using relevant keywords [supply chain transportation, disruptions in supply chain transportation, risks of transportation in supply chain].
2) Search for literature; Use academic search engines such as Google Scholar, Scopus, and Web of Science for relevant literature.
3) Screen and select articles: Review the abstracts and titles of the articles to determine their relevance to the research scope.
4) Synthesise and analyse the literature.

Categorising different types of problems within the research helps to identify and understand the specific challenges and complexities associated with each problem area, hence, identifying the disruption factors of each transportation problem. The categories based on the selected articles are; *Carrier Selection, Transportation Design, Route Optimisation and Transportation Planning and Scheduling.*

B. Literature in Carrier Selection

Researchers have examined various aspects of outsourcing in supply chain management. Haung et al. (2019) studied the impact of outsourcing prices on supply chain performance, while Kantari et al. (2021) investigated transportation costs and delivery time for contract-based and spot-market transporters. Alkhatib (2017) proposed a mixed-methodology approach to evaluate 3PLs outsourcing strategy objectives in upstream and downstream supply chains. Yazdani et al. (2017) developed a multi-criteria decision-making model for selecting carriers, highlighting the importance of customer satisfaction rates. Other studies have focused on the impact of outsourcing on supply chain effectiveness, including Mubarik et al. (2012), who investigated the relationship between transportation outsourcing and supply chain performance, and Bulgurcu et al. (2018), who proposed a generic framework for logistics provider selection criteria. Ecer (2018) developed a fuzzy integrated model to evaluate and select carriers based on qualitative and quantitative criteria. Additionally, Wang et al. (2021) proposed a hybrid multi-criteria optimisation model for selecting carriers based on supply chain sustainability factors, while Diego et al. (2012) developed a mathematical model for evaluating carriers in the defence industry.

C. Literature in Transportation Design

Several studies have examined transportation design in supply chain management. Tsao et al. (2012) considered freight discounts and supplier credit in their multi-item transportation design model, while Roy (2020) compared multiple-item designs to reduce transportation costs. Zhang et al. (2014) proposed a logistics network design model that optimises transportation operations and location, considering order quantity. Olivares-Benitez et al. (2013) investigated the optimal transportation and facility costs of a supply chain design problem. Fisher Ke et al. (2015) examined how industry characteristics affect global supply chain transportation design, specifically financial flow and transportation strategy relationships. Hasani et al. (2016) proposed a robust model design for the global supply chain under uncertainty and disruptions to maximise total profits. Hiremath (2012) also formulated a mixed-integer linear programming model to minimise manufacturing supply chain costs and maximise unit fill rates. Finally, Xiang Ji et al. (2015) conducted an empirical study on transportation eco-design to identify the Pareto Optimal transportation strategy for improving supply chain sustainability, with lead time being the primary factor.

D. Literature in Route Optimisation

Considerable attention was provided in the literature on Route Optimisation problems of supply chain transportation. For example, Spiegler et al. (2014) developed collaborative scenarios that minimised transportation and inventory costs. On the other hand, Chan et al. (2011) developed three simulation models to examine the impact of collaborative transportation management on the supply chain. On the other hand, Arkan et al. (2012) investigated coordination processes in a two-echelon supply chain. Chung et al. (2018) investigated the impact of uncertain 3PLs lead-time and safety stock levels on JIT supply chain logistical performance. Freile et al. (2020) found the optimal integrated decision of the supply chain in terms of transport capacities, inventory levels, and costs in a food supply chain. In their 2019 study, Li et al. investigated the influence of lead times on sustainable supply chain performance by creating a system dynamic simulation model that accounts for uncertain stochastic lead times levels.

E. Literature in Transportation Planning & Scheduling

Several studies have addressed transportation planning and scheduling management. Günther et al. (2010) developed a generic approach based on transportation network conditions and freight rate structures to address operational transportation planning between facilities, suppliers, and warehouses. Fathian et al. (2016) suggested a fuzzy nonlinear programming model to tackle supply chain design and planning issues related to traffic congestion and supply/demand uncertainties while also considering the sustainable aspect of transportation planning. Chern et al. (2010) proposed a heuristic algorithm called Emergency Relief Transportation Planning Algorithm (ERTPA) to manage aftershock demand planning. Zhang et al. (2020) solved the dynamic transportation planning problem for the Prefabricated Component Supply Chain (PCSC), while Jung et al. (2010) proposed a heuristic using a genetic algorithm to solve a serial supply chain transportation planning problem. Martin Steinrücke (2011) and Tien-Fu Liang (2007) have also explored the integration of production and transportation planning and scheduling to minimise total costs.

Reference	Methodology	Disruptions
Huang et al. (2019)	Mathematical Programming	X
Diego et al. (2012)	Mathematical Programming	X
Kantari et al. (2021)	Simulation	X
Alkhatib (2017)	Fuzzy	X
Yazdani et al. (2017)	Fuzzy	X

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(Bulgurcu & Nakiboglu, 2018)	Fuzzy	X
Ecer (2018)	Fuzzy	X
Wang et al. (2021)	Fuzzy	X
Mubarik et al. (2012)	Questionnaire	X

Table. 1. *Summary of Carrier Selection Literature*

F. Identification of Disruptions in Supply Chain Transportation Problems.

This section summarises the selected articles, which are based on different problems in supply chain transportation. A comparison among them is needed to highlight the methodology used and the attention to disruptions. Table 1 shows that the Fuzzy method was used most in the Carrier selection problems. It bears noting that no study in carrier selection has considered the disruptions. While in Table 2, the literature on Transportation design adopted mathematical models widely. However, the disruptions were considered by (Zhang and Xu 2014, Hassani and Khosrojerdi 2016), where stochastic disruptions and Natural disasters were considered, respectively.

Reference	Methodology	Disruption
Fisher Ke et al. (2015)	Regression	X
Hasani and Khosrojerdi, 2016)	Heuristic Algorithm	Yes
Hiremath. N et al. (2013)	Mixed-Integer	X
Olivares et al. (2013),	Mixed-Integer	X
Zhang and Xu, 2014	Mixed-Integer	Yes
Ji et al. (2016)	Mathematical Programming	X
Roy, M. Das (2020)	Mathematical Programming	X
(Tsao and Lu, 2012)	Mathematical Programming	X

Table. 2. *Summary of Transportation Design Literature*

On the one hand, in Table 3, researchers have studied supply chain transportation in a Routing Optimisation problem considering uncertain stochastic lead time and safety stock delay as a disruption factor (Li et al. 2019).

Reference	Method	Disruption
(Arkan and Hejazi, 2012)	Mathematical Programming	X
(Spiegler and Naim, 2014)	Simulation	X
(Chan and Zhang, 2011)	Simulation	X
Freile et al. (2020)	Simulation	X
Chung et al. (2018)	Simulation	X
Li et al. (2019)	Simulation	Yes

Table. 3. *Summary of Route Optimisation Literature*

On the other hand, Fathian et al. (2016) considered disrupted demand and traffic as disruption factors in their transportation problem in planning and scheduling. At the same time, Tien-Fu Liang (2007) considered stochastic uncertainty in scheduling transportation. Table 4 presents the planning and scheduling literature.

Reference	Method	Disruption
(Günther and Seiler, 2009)	Mathematical Programming	X
Chern et al. (2010)	Heuristic Algorithm	X
(Jung and Lee, 2010)	Heuristic Algorithm	X
Tien-Fu Liang (2007)	Fuzzy	Yes
(Zhang and Yu, 2020)	Computational Modelling	X
Fathian et al. (2016)	Fuzzy	Yes
(Jung and Lee, 2010)	Heuristic Algorithm	X

Table. 4. *Summary of Planning and Scheduling Literature*

The literature and summary table 4 identifies the diversified methodologies used in supply chain transportation problems. It shows that Fuzzy, Mathematical Programming and Simulation received substantial attentiveness from researchers. It bears noting that few studies considered the disruptions in transportation problems. For example, the Carrier Selection problem has, so far, no study considering disruptions. Transportation Planning and Scheduling problems have two studies, while Route Optimisation and Transportation have one. Hence, this limitation unwraps the gap in knowledge of disruptions in supply chain transportation problems. Therefore, a comprehensive analysis to develop a framework that captures different disruption factors and their relationship is crucial for future research.

III. METHODOLOGY

The operations of supply chains involve receiving orders, processing information flow, and preparing and shipping goods. If any disruption occurs, it can lead to difficulties for the entire supply chain. The literature review highlights that disruptions can take different forms and affect various aspects of the supply chain, with transportation being one of the most affected. The COVID-19 pandemic has exacerbated the impact of these factors by introducing new restrictions, lockdowns, and safety measures that have disrupted transportation processes and management. Previous research has mostly focused on production problems, breakdowns, disruptions, and optimisation in the supply chain, leaving other disruption factors less explored. These factors significantly impact supply chain transportation selection management, as shortages in drivers or trucks can lead to volatile prices and cause massive delays at checkpoints due to tests and inspections.

Additionally, COVID-19 has caused significant shifts in customer behaviour, affecting the quantity, sequence, and preferences of orders and disrupting the supply chain's flow of goods, information, and financial components. As a result, credit terms with stakeholders, including carriers, have been affected, and volatile transportation rates have increased due to transportation companies' restrictions, resource problems, and

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additional operating costs. The following framework in Figure 1 presents the selected disruption factors, their interchanging relationships, dependencies, and interdependencies.

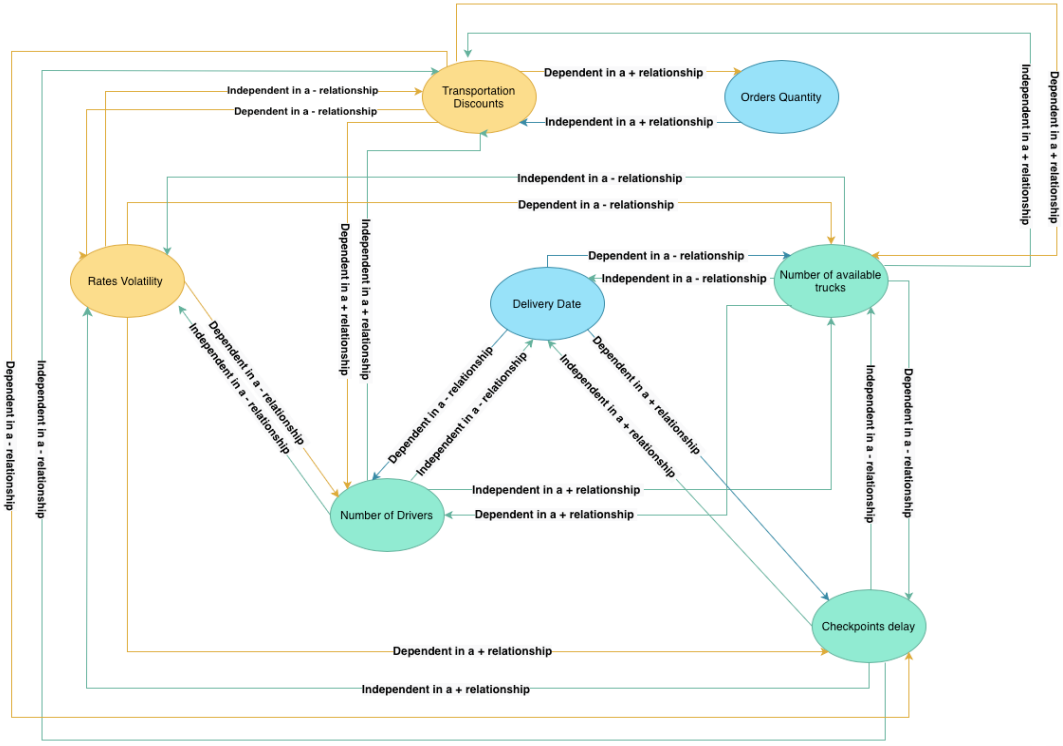

Figure 1. Relationship diagram of the disruption factors

It is observed that transporters' rates and their availability are in a reverse relationship, complying with the findings of (Kantari et al. 2021). The trucks and drivers represent the availability of the transporters. The literature also revealed the existence of negative influence of the transportation companies' resource availability, such as drivers and trucks on the delivery dates scheduled for the supply chain orders, discount offers, and the rate's volatility. The checkpoint's delay factor affects both supply chains and transportation companies. It is an independent disruption factor in most of its relationships. Due to the uncertain and unpredicted nature, it can cause a significant decrease in the available trucks. They spend extra time, resulting in higher volatility in transportation rates, fewer discount offers, uncertain delivery dates, and delay for the supply chain orders. To summarise the relationship between the proposed factors. The checkpoint delay, number of drivers, number of available trucks, and order quantity factors influence most of the remaining factors.

Additionally, the dependency on delivery date and the financial factors is highlighted. The relationships among those selected factors or other disruption factors are helpful to recognise a thorough impact on the supply chain. This can help the enterprises to construct plans for hedging the risks, identifying the source of the disruptions and working meticulously with partners to avoid severe damages.

IV. Discussions and Recommendation

Generally, supply chain transportation is a crucial aspect of supply chain management, as it involves the movement of goods from one place to another, impacting the entire supply chain's performance. As mentioned, the outbreak of the COVID-19 pandemic has magnified the importance of supply chain transportation, and many companies have faced significant disruptions due to the restrictions, lockdowns, and strict safety measures enforced by governments. Identifying the disruption factors and understanding their relationship is essential for supply chain managers to minimise the negative impact of disruptions on transportation processes.

In a competitive and connected business world, disruptions, whether the cause is Wars, Pandemics, or political policies, are more likely to occur. Their factors can vary; they affect different aspects of transportation and the overall supply chain, making it crucial to understand their interdependence. The identified factors include, but are not limited to, transportation discounts, checkpoints delay, driver shortages, truck capacity, customer preferences, delivery dates, financial flows, and volatile transportation rates. The reviewed literature shows that disruption factors in supply chain transportation are not well considered.

A useful computerised technique can serve the supply chain to act agilely into risks and disruptions. By quantifying the relationships of the factors and identifying their sources, the decisions in transportation could hedge serious losses and

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improve the performances in a disrupted environment. Future research in this aspect can focus on developing models to assess the impact of disruption factors on supply chain transportation processes and develop methods to mitigate their negative impact. Additionally, researchers can explore emerging technologies such as blockchain, the Internet of Things (IoT), and Artificial Intelligence (AI) to improve supply chain transportation processes' efficiency and resilience.

V. CONCLUSION

After conducting a thorough literature review on supply chain transportation problems, this study identified four problems aspects for transportation, including Carrier Selection, Transportation Design, Route Optimisation, and Transportation Planning and Scheduling. The study also analysed the transportation problems aspects under disruptions and risks, which identified the limitation in considering disruptions in the transportation problems of the supply chain, precisely, the Carrier Selection. This gap formed the motivation to analyse literature and propose a framework to investigate selected disruption factors and structure the relationships between them to implement future policies that cover multiple risk factors. However, the study is limited by the inconsistent literature on transportation selection decisions under disruption environments and different factors. To address this limitation, future research should focus on developing computerised models to quantify the qualitative findings and simulate the interchanging relationships to recommend optimal decisions for the supply chain components. Such an approach would be a powerful method to address the complex nature of factor types and their impacts on each other and the supply chain transportation selection decision-making.

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