



CHALMERS

Strategies for building Supply Chain Resilience

A Comprehensive Review with Insights from the Freight Forwarding Industry

Bachelor thesis for International Logistics Program

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CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2024

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PREFACE

This thesis, executed within the framework of the International Logistics Programme at Chalmers University of Technology, has been a part of our education which in total comprises 180 credits. This specific work accounts for 15 of these credits.

The project has involved a collaboration with an anonymous participating company and expert in the field, whose insights and data have been important for our research. We are deeply grateful for their commitment and support. We would like to extend special thanks to our supervisor, Selma Brynolf, for her valuable guidance and expertise.

By exploring strategies to improve the resilience of supply chains during global disruptions, this work has not only broadened our academic understanding but also enhanced our practical know-how. We have learnt the importance of resilience and adaptability in an ever-changing world.

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SAMMANDRAG (in Swedish)

Denna rapport undersöker speditorsbolagens strategier för att förstärka deras leveranskedjors motståndskraft under globala störningar. På senare år har störningarna i leveranskedjan ökat, vilket understryker vikten av motståndskraft för att hantera dessa utmaningar. Begreppet motståndskraft i leveranskedjan har utvecklats till att fokusera mer på proaktiv identifiering av hot och snabb återhämtning, med hjälp av avancerad teknik och ökad flexibilitet och samarbete.

Genom en kombinerad metod som omfattar en litteraturöversikt, en modellansats och genomförda av två intervjuer, har vi utforskat och analyserat hur företag kan hantera och minimera effekterna av störningar i leveranskedjan. Litteraturöversikten bidrog med en djupgående förståelse av begreppet leverans kedjans motståndskraft och de varierande definitioner som existerar inom ämnesområdet. Vi utvecklade T-IRRA-modellen, vilken fokuserar på de fem faserna: transparency, identify, respond, recover, och advance. Ett ramverk för att systematiskt kunna analysera och förbättra leverans kedjans motståndskraft. Transparens utgör inte en egen fas, utan framträder istället som ett genomgående centralt tema i samtliga faser. Intervjuerna med experter från både praktiska och teoretiska perspektiv, användes för att validera modellen och integrera praktiska insikter i vår analys.

Resultaten visar att transparent kommunikation och aktivt engagemang från alla intressenter är avgörande för att effektivt hantera störningar. Vidare är integrationen av avancerad teknik som IoT och AI kritisk, men kräver betydande investeringar och starka data skyddsåtgärder. Kontinuerligt lärande och utveckling är avgörande, med utvärdering efter störningar och kunskapshantering som stärker motståndskraften. Denna rapport ger praktisk vägledning för speditörer som strävar efter att stärka sin leveranskedjas motståndskraft i en komplex bransch.

Nyckelord: supply chain resilience, supply chain disruptions, freight forwarders

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ABSTRACT

This report examines freight forwarders' strategies to strengthen the resilience of their supply chains during global disruptions. In recent years, supply chain disruptions have increased, emphasizing the importance of resilience in managing these challenges. The concept of supply chain resilience has evolved to focus more on proactive threat identification and rapid recovery, utilizing advanced technologies and fostering collaboration and flexibility.

By using a combined methodology of a literature review, a modeling approach and conducting two interviews, the report explores and analyzes how companies can manage and minimize the impact of supply chain disruptions. The literature review provided an in-depth understanding of the concept of supply chain resilience and the varying definitions that exist in the field. A developed model called T-IRRA, which focuses on five phases named transparency, identify, respond, recover, and advance, is set as a framework to systematically analyze and improve supply chain resilience. The interviews, with experts from both practical and theoretical perspectives, were used to validate the model and integrate practical insights into our analysis.

The results show that transparent communication and active involvement of all stakeholders are crucial to effectively manage disruptions. Furthermore, the integration of advanced technologies such as IoT and AI is critical but requires significant investment and data protection measures. Continuous learning and development is essential, with post-disruption assessment and knowledge management strengthening resilience. This report provides practical guidance for freight forwarders striving to strengthen their supply chain resilience in a complex industry.

Keywords: supply chain resilience, supply chain disruptions, freight forwarders

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ACRONYMS AND TERMINOLOGY

SCR	Supply Chain Resilience
SCRES	Supply Chain Resilience
SCD	Supply Chain Disruption
SCM	Supply Chain Management
FF	Freight Forwarders
IOT	Internet of Things
AI	Artificial Intelligence

1. INTRODUCTION

In recent years, unpredictable events or supply chain disruptions have been one of the biggest challenges for businesses across all industries, as the number of global supply chain disruptions increased by over 300% from 2019 to 2021 (Statista, 2022). The capability to mitigate these disruptions is called supply chain resilience, a concept based in supply chain management. The term supply chain resilience increased to appear in publications around 2000, connected to the impacts caused by events such as fuel protests, diseases and terrorist attacks (Kummer et al., 2022). However, it was first after the oil spill in the Gulf of Mexico in 2010, that the concept was increasingly used in supply chain management according to Pettit et al., (2019). Supply chain resilience has in recent years become more relevant, as two specific disruptions are often referred to, COVID-19 and the Ever Given's incident in the Suez Channel. These visualized the vulnerability of the global supply chain network and simultaneously increased the recognition of building a resilient supply chain.

The term supply chain resilience carries a weight of history that informs its meaning and shapes the way we operate in the transport industry today. While recent disruptions like pandemics and wars might make it seem like a new concept, the core principles have been around for much longer. Early discussions prioritized control, reflecting a more stable global environment (Wilding & Wagner, 2012), while today, more focus is on how to proactively identify threats using advanced technologies and the increased focus on rapid recovery from disruptions. Terms such as collaboration and flexibility are also becoming extremely well known in the concept (Deloitte, 2023).

In the complex industry of global trade, freight forwarders play an essential role that often goes unnoticed. They act as intermediaries between exporters, importers, and various transport providers, organizing an efficient movement of goods across borders and continents. They handle important tasks such as cargo consolidation, route optimization, customs clearance, and documentation, ensuring efficient transport (Skiba & Karas, 2022). Freight forwarders bring value to the global supply chain when they create solutions that match perfectly with customers' needs. The world of supply chains has become increasingly complex. Globalization, diverse sourcing strategies and rapid technological advances have created a network of complex connections that are both beneficial and vulnerable.

Disruptions such as pandemics, trade wars and geopolitical tensions can easily upset this fragile balance, significant challenges for businesses (Shih, 2020). Group Chairman and CEO of DP World, Sultan Ahmed bin Sulayem, states that the logistic sector must create new tools to tackle the uncertain times (DP World, n.d).

1.1 AIM OF THE STUDY

The aim of the report is to understand how freight forwarders involved in a supply chain can build resilience to strengthen their logistical network. The report examines the proactive efforts freight forwarding companies do to prevent disruptions from occurring, as well as their actions to recover and rebuild.

1.2 RESEARCH QUESTIONS

1. What strategies do freight forwarders use to proactively identify and manage potential disruptions in their supply chain?
2. How can companies efficiently process their actions to quickly recover from a disruption in the supply chain and minimize the overall impact?

1.3 DELIMITATIONS

This report is limited to freight forwarders and their supply chain resilience, specifically focusing on the period from 2015 to 2024. It concentrates on large global companies with over 500 employees, due to their significant role in the global freight industry and their capacity to provide data. It does not consider parameters such as economic factors, environmental concerns that also may impact supply chains.

2. THEORY

This section outlines the evolution of supply chain management from its logistics roots to a comprehensive strategy enhancing business efficiency. This involves an explanation of the concept supply chain resilience, emphasizing the ability to anticipate, respond to, and recover from disruptions to maintain operational continuity. Finally, this section highlights the importance of understanding the concept of supply chain resilience.

2.1 SUPPLY CHAIN MANAGEMENT

“Supply chain management” first started to appear in literature in 1982 (Oliver & Weber 1982) and was then used to describe the connecting logistics with other functions. The term was also used to describe the connections between logistics, internal operations, and external organizations (Houlian, 1985). In more recent year’s supply chain management involves handling all activities of the entire production flow of goods or a service (SAP, n.d.). Implementing supply chain management can transform businesses and lead to increased competitiveness, efficiency, and cost-reduction (Khojasteh, 2018), as well as understanding the complexity of supply chain management can optimize supply chain operations and aim to achieve strategic objectives within businesses.

2.2 SUPPLY CHAIN RESILIENCE

The term supply chain resilience is a concept found in supply chain management together with supply chain vulnerability (Juttner & Maklan 2011), enabling supply chains to react to supply chain disruptions. The definitions of the concept vary, as goes for the different explanatory elements, see a summary of definitions in Table 1. In Cambridge Dictionary the concept does not have an official definition. However, by breaking it down, supply chain is defined as “the system of people and things that are involved in getting a product from the place where it is made to the person who buys it.” Resilience on the other hand, is defined as “the quality of being able to return quickly to a previous good condition after problems” (Cambridge University Press, n.d.). While Ponomarov and Holcomb (2009) defines supply chain resilience as “the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.”

The concept is as mentioned defined by various characteristics and definitions. At its core, supply chain resilience is centered on the capacity of a supply chain to mitigate the impacts of disruptive events, ensuring operation consciousness without uncertainty. Adaptability, preparedness, flexibility is among elements used in literature.

Risk management is part of supply chain resilience since many risks cannot be predicted or avoided (Christopher & Peck, 2004). It can help to reduce the vulnerabilities of the supply chain by forecasting, observing and mitigating risks (Rajesh & Ravi, 2015). However, to understand and share risks among partners, risk management culture must extend beyond the division of the organization (Christopher & Peck, 2004).

Supply chain resilience underscores the importance of proactive risk management and contingency planning, as supply chains must actively identify and assess potential vulnerabilities in the chain. Initiatives for addressing these include shaping a risk management culture in organizations (Christopher & Peck, 2004). This approach empowers anticipation and preparation for disruptions, to minimize their impact and implement rapid recovery. Supply chain resilience represents a dynamic approach to supply chain management, emphasizing the importance of several elements to navigate the uncertainties of the business environment. If organizations embrace strategies and principles of supply chain resilience, they can ensure their continuity of operations and value to their customers.

2.2.1 DEFINITIONS OF SUPPLY CHAIN RESILIENCE

Supply chain resilience, often referred to as SCR or SCRES, summarize the ability of a supply chain system to deal with disruptions and efficiently recover to its original or improved state. It involves proactive planning, adaptability, and responsive actions to maintain control. Below table is a selection of definitions of supply chain resilience from various sources.

Table 1*Definitions of supply chain resilience based on literature review.*

SOURCE	DEFINITION
Falasca et al. (2008)	SCR is the ability of a supply chain system to reduce the probabilities of a disruption, to reduce the consequences of those disruptions once they occur, and to reduce the time to recover normal performance.
Christopher & Peck, (2004)	The ability of a system to return to its original state or move to a new, more desirable state after being disturbed.
Zsidsin & Wagner, (2010)	Supply chain resiliency consists of the ability to return to normal performance levels following a supply chain disruption.
Xiao et al. (2012)	Supply chain resilience can be defined as the supply chain's ability of returning to the original or ideal status when this supply chain system has been disturbed by external interruption, and resilient supply chain shows that this supply chain has the two abilities on adaptability to environment and recovering ability of the system
Ponis & Koronis, (2012)	SCRES is the ability to proactively plan and design the supply chain network for anticipating unexpected disruptive (negative events), respond adaptively to disruptions while maintaining control over structure and function and transcending to a post robust state of operations, if possible a more favorable one than that prior to the event, thus gaining a competitive advantage
Closs & McGarrell, (2004)	SCRES is the supply chain's ability to withstand and recover from an incident. A resilient supply chain is proactive–anticipating and establishing planned steps to prevent and respond to incidents. Such supply chains quickly rebuild or re-establish alternative means of operations when the subject of an incident

2.3 SUPPLY CHAIN DISRUPTIONS

Followed by supply chain resilience, the recent years have increased the understanding of the impact a supply chain disruption can cause. The defined “internal or external event that affects the current or planned flow of goods or services in a supply chain” (Khojasteh-Ghamari & Irohara, 2018), has become one of the main concerns for organizations that make efforts to improve their supply chain resilience. Hence, supply chain disruptions is a fundamental requirement of the supply chain resilience concept. By understanding the risks that’s associated with supply chain disruptions, organizations can implement resiliency strategies and develop mitigation to help aid these (Supply Chain Management, 2017). One of the most recognizable disruptions, COVID-19, exposed the global supply chains vulnerability, showcasing the effect of supply chocks, increased demand from customers during temporary trade restrictions (Harvard Business Review, 2020). Another recent example is the accident of the container ship Evergreen in the Suez Channel. Stopping traffic between Europe and Asia for six days, causing a backlog with over 400 vessels and a loss of billions in trade (The Guardian, 2021). Both disruptions visualize the effect of unpredictable events and how important supply chain resilience is. Commonly supply chain disruptions can be categorized by type. Bugert and Lasch (2018) presents two categories, natural and man-made. Where the Taiwan earthquake of 1999 falls into natural, including severe weather conditions, disease outbreaks and geological events. While 9/11 categorized as a man-made disruption with accidents, terrorist attacks and labor strikes. The evolving understanding of supply chain disruptions underscores the importance of supply chain resilience, as the two terms are deeply connected to each other. The ability to recognize and proactively address the risks that follows from a certain disruption ensures the supply chain can continue their supply chain operations successfully.

3. METHOD

This thesis is divided into three sections, a literature review, a model approach and two conducted interviews. Literature review was used to collect information about the concept and to understand the complexity of its use. The model approach was used to provide another perspective on the concept together with the two interviews which were performed to verify the approach as well as useful information around the topic.

3.1 LITERATURE REVIEW

The report utilizes a qualitative research method to answer the survey questions. According to Machi and McEvoy (2022) a literature review supports a thesis by building a case from evidence obtained from previous research. The research process started by collecting information around the topic, the concept of supply chain resilience. Search terms such as “supply chain resilience”, “supply chain disruptions”, “supply chain management”, “supply chain” and “freight forwarders” were used to gather literature from various sources. Our starting points were academic databases such as Chalmers Library, Scope and Google Scholar. After the initial research, we understood the problem around the concept which helped design our two research questions. Continuing, literature made us discover the variety in definitions of supply chain resilience. Due to the differences in takes of the concept, we decided to design a table (see Table 1) with several definitions from relevant articles located in previously mentioned databases as well as several different publishers such as Emerald, Elsevier, Springer and IEEE.

3.2 MODEL APPROACH

The model approach started with a similar methodology as the literature review. However, using search terms such as “elements”, “characteristics”, “stages” and “phases” in combination with “supply chain resilience” instead. After the initial approach, two tables were conducted (See Table 2 & Table 3) to display the differences in various elements and stages of supply chain resilience. For Table 2 we used the specific terms as “elements” and “characteristics” in combination with “supply chain resilience”, to understand what concepts serve to be crucial for building supply chain resilience according to the sources. Following this approach such as Ke et al. (2023), these elements were gathered in a first conducted table linked together with the source.

For Table 3 we used the same approach as the previously mentioned table. However, terms as “stages” and “phases” were used in combination with supply chain resilience instead. This methodology helped us understand which elements that could be found in the different stages from handling a supply chain disruption. This method also supported the construction of the T-IRRA model, as we gathered inspiration from the sources to identify which elements, we assumed were crucial for the different phases. After the initial research and construction of the two tables, we assembled four main phases. These were named “Identify”, “Respond”, “Recover”, and “Advance” which can be described as the transitions of a supply chain disruption, from. Additionally, the model also includes the key element “Transparency”, a fundamental factor involved in all the phases, due to its common involvement in elements of the sources we gathered. This combination of the literature research, to first collect individual elements of supply chain resilience and then connect the elements together with phases helped to develop the T-IRRA model. The model was created to analyze how freight forwarding companies could sustain supply chain resilience within a clear framework.

3.3 INTERVIEWS

Two interviews were conducted in this report with the aim to provide a different perspective to our result. The first interview was semi-structured, performed through an online meeting on Microsoft Teams with “Respondent 1”. This interview was conducted to provide flexibility for additional questions, allowing the interviewer to explore various avenues without constraint (Bell, Bryman, & Harley, 2022). The questions were related to the concept of supply chain resilience and contained connecting questions to our own model (see Appendix 1). The structure of this interview helped to ensure the validity of the model approach and provided insights of how particular designed risk management teams connected to the concept, operate daily. The second interview with “Respondent 2”, followed with similar but slightly adjusted questions compared to the first (see Appendix 2). This interview was instead conducted through email interaction only. The questions were adapted for the second interview due to relevance, as the respondent’s daily interaction with the concept was different compared to the first respondent. Both interviews ensured that our model was valid for describing our take on supply chain resilience’s different stages and provided a different perspective to the result.

The process to find “Respondent 1” started with looking for potential companies to interview related to the topic of the report. As it revolved around freight forwarders, the first step began with contacting and sending out requests to freight forwarding companies located in our local area by email. Twenty different companies were contacted, which of one led to an interview. The other nineteen companies that were contacted did either not respond to the request or it proceeded to a declined arranged interview. An uncertainty of the concept was recognized by most of the contacted companies, which arguably would lead to not proceeding the request of a potential interview further. Due to lack of time, the decision to proceed with the one interview we performed was taken, as it covered a lot of how to work with supply chain resilience daily. After the first interview process was finalized the seeking for further respondents continued. By exploring current professors with connections to the concept, a contact to “Respondent 2” was performed, one with significant working experience within the field. The communication with this respondent quickly led to the second interview in the report.

Even though the process of the interview did not turn out as expected from the start, both respondents’ time and knowledge were greatly appreciated. As the respondents both have different backgrounds when it comes to the concept of supply chain resilience, their participation was valuable for the report. Important to note is that while the interviews served as a complement to our literature review, it was also aimed to validate and enhance our understanding of the insights gathered from existing literature as well as a confirmation of a relatable model approach. By comparing and integrating the insights from both the primary sources and the secondary, the results aimed to provide reliability of our analysis.

3.4 ETHICS

Ethical considerations played a crucial role throughout our research process, guiding our actions and decisions to ensure the reliability and validity of the study. Throughout the research process, we were carefully conscious of the four main areas that need to be considered according to Bell et al. (2022). We carefully reviewed whether there was any risk of harm to the participants and took steps to minimize any potential inconvenience.

In addition, we ensured that all participants gave their informed consent before participating in the study and understood the purpose and requirements of their participation. In line with ethical principles, we chose to anonymize the interviews to protect the privacy and confidentiality of the participants. Respondents expressed a preference for anonymity, and we believed that anonymizing the interviews would contribute to a more professional and respectful research environment. This decision was made to ensure that participants felt comfortable sharing their experiences and perspectives openly and honestly. By anonymizing the interviews, we aimed to create a safe space for participants to express themselves without fear of repercussions or exposure.

3.5 RELIABILITY

It may be difficult to measure reliability if a literature review has been used as the method is relatively open and not particularly strict (Bell et al., 2022). But to ensure the reliability of our report, we have taken several actions throughout the research process. Firstly, we have carefully selected interviewees and applied a strict selection process to ensure that our data sources are reliable and relevant to our topic. We have used both primary and secondary sources to gain a broad and in-depth understanding of the concept under review.

To ensure the reliability of our report and identify any weaknesses, we conducted a pre-study to test our model and research methods before embarking on the larger study. The pre-study was carried out in collaboration with two experts who we interviewed; one from the freight forwarding industry and one from Chalmers University of Technology. During the interviews, the experts gave us valuable feedback on our methods and tools, especially our T-IRRA model. The expert from the freight forwarding industry shared practical insights and industry-specific challenges that helped us fine-tune our model to better reflect real-life conditions. The expert from Chalmers University of Technology contributed academic and theoretical knowledge that ensured our methods were scientifically and methodologically correct. By analyzing and applying their feedback, we were able to identify and fix potential problems in our model before starting the real results part. This process was crucial to strengthen the reliability in our report.

3.6 VALIDITY

According to Bell, validity is essential to ensure that a report correctly and reliably measures and represents the indicators that the study intends to investigate. To ensure the validity of our research, we have used several strategies. In particular, we have used a CRAAP evaluation to assess the validity and relevance of our sources. CRAAP stands for Currency, Relevance, Authority, Accuracy, Purpose and Publications. While CRAAP primarily evaluates the reliability and quality of sources, it also plays a crucial role in providing a preliminary assessment of their validity. By examining aspects such as the relevance and accuracy of the information, as well as the authority and purpose of the source, we can assess how well the sources match our research objectives and whether they accurately represent the parameters we aimed to investigate.

To ensure the reliability of the sources in our CRAAP evaluation, we conducted a review based on the following criteria. We evaluated how the information provided by the source contributed to our understanding of the topic and its connection to our research. We reviewed the source information carefully to identify any errors or gaps. We selected sources that were properly researched and verified to ensure reliability. We analyzed the source's purpose to assess any possible bias or motives that might affect the objectivity of the information. We looked for sources with a clear and unbiased purpose that was in line with our research objectives. Finally, we evaluated the form of publication and origin of the sources to determine their credibility and reliability. We prioritized sources published in scientific journals, books, or official websites. By applying these strict criteria, we were able to identify and use the most relevant, credible, and reliable sources to support our research.

4. RESULTS

This section outlines the key findings from our research into the elements and stages critical for supply chain resilience. We introduce the T-IRRA model, a framework derived from our analysis, which details the essential components and stages needed to strengthen resilience against disruptions. The following subsections will detail how these elements enhance the resilience of supply chains and integrate within the T-IRRA model to offer practical strategies for managing disruptions.

4.1 ELEMENTS OF SUPPLY CHAIN RESILIENCE

This subsection is set to gather sources that identify certain elements connected to achieving supply chain resilience. The selected elements were first collected and gathered from the source, to then influence the creation of the T-IRRA model, as mentioned in the methodology. Frequently used elements as flexibility, redundancy, collaboration, visibility, agility, and information sharing, all increase the possibility of mitigating supply chain disruptions according to the sources. Hohenstein et al. (2015) reviewed 67 peer-reviewed articles and identified four phases in supply chain resilience: readiness, response, recovery, and growth. The review also identified elements important for supply chain resilience, where the most stressed elements were flexibility, redundancy, collaboration, visibility, agility, and multiple sourcing. Kamalahamadi et al. (2016) instead used/or similarly used collaboration, agility, trust, redundancy, information sharing, innovation, and visibility. Both Naimi et al. (2022) and Stone and Rahimifard (2018) mentions Risk management as fundamental to sustain supply chain resilience, while Ali and Gölgeci (2019) brings up the use of technology as a crucial element.

Table 2*Elements of supply chain resilience based on literature search in 3.2 model approach*

SOURCE	ELEMENTS
Hohenstein et al. (2015)	Flexibility, Redundancy, Collaboration, Visibility, Agility, Multiple Sourcing, Capacity, Information sharing
Kamalahmadi et al. (2016)	Collaboration, Agility, Trust, Redundancy, Information sharing, Innovation, Visibility
Naimi et al. (2022)	Flexibility, Redundancy, Trust, Information sharing, Collaboration, Visibility, Risk management culture, Multiple sourcing, Readiness, response and recovery, Efficiency, Anticipation
Ali and Gölgeci (2019)	Flexibility, Information sharing, Supply chain innovation, Adaptation, Supply chain redesign, Technology
Stone and Rahimifard (2018)	Flexibility, Redundancy, Contingency plans, Knowledge management, Collaboration, Agility, Visibility, Risk management orientation, Responsiveness, Efficiency

4.1.1 STAGES WITH CONNECTED ELEMENTS OF SUPPLY CHAIN RESILIENCE

This subsection summarizes sources which present different elements that specifically are linked to different stages of achieving supply chain resilience. The stages represent different parts in the process of handling a supply chain disruption with linked elements in the third column, serving to be specific characteristics within the stages. As mentioned in the methodology the stages influenced the creation of the T-IRRA model and helped to select elements which were essential characteristics of the phases in T-IRRA. Han et al. (2015) conducted a literature-review of 153 papers and identified four phases in supply chain resilience: readiness, response, recovery, and growth, pointing to elements such as agility, flexibility and collaboration for the readiness stage, which is similar to the identify phase of T-IRRA. Continuing, the authors recognize advancement from disruption and name the stage growth, while Ali et al. (2017) uses learn, where knowledge management is underscored.

Stages response and recovery occurs in all of the sources and includes important elements as knowledge management, planning, risk awareness, flexibility and agility.

Table 3

Stages combined with elements of supply chain resilience based on literature review.

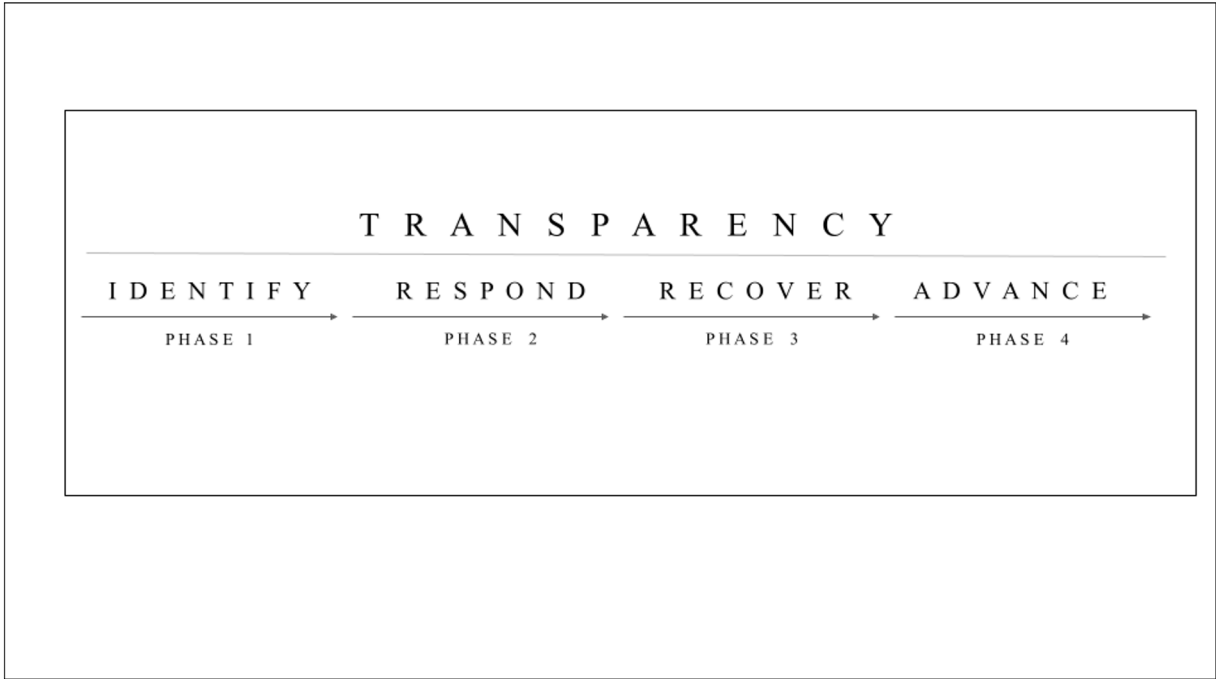
SOURCE	STAGES	ELEMENTS
Han et al. (2020)	READINESS RESPONSE RECOVERY GROWTH	READINESS - Agility, Flexibility, Collaboration RECOVER - Knowledge management, Planning
Ali et al. (2017)	ANTICIPATE RESPOND RECOVER LEARN	ANTICIPATE - Situation awareness, Visibility RESPOND - Collaboration, Agility RECOVER - Contingency planning LEARN - Knowledge management
Singh et al. (2019)	ANTICIPATION RESPONSE RECOVERY	ANTICIPATION - Visibility, Awareness RESPONSE - Agility RECOVERY - Planning
Scholten et al. (2014)	PREPAREDNESS RESPONSE RECOVERY	PREPAREDNESS - Planning, Information sharing RESPONSE - Flexibility, Agility RECOVER - Risk awareness, Knowledge management

4.2 T-IRRA MODEL

Based on the literature review and specifically the elements summarized in Table 2 and table 3 we developed the model T-IRRA.

Figure 1

Visualization of the T-IRRA model



The model contains four key phases: Identify, Respond, Recover and Advance. Transparency is also part of the model but is not a separate phase as it is included in all of them. The T-IRRA model provides a framework for understanding and implementing supply chain resilience.

Table 4*Phases and description of the T-IRRA model*

PHASES	DESCRIPTION
IDENTIFY	Identify is an proactive phase focused on forecasting potential disruptions before they occur. Companies use risk analysis techniques to identify areas of vulnerability within their supply chain.
RESPOND	Respond involves the immediate actions taken after a disruption occurs, quick and resolute actions that can be crucial. Effective response means minimizing the damage caused by the disruption. This may include allocating resources to mitigate the impact, prioritizing customer needs and showing flexibility in adapting operations.
RECOVER	Recovery aims to restore normality to operations as quickly and efficiently as possible. A well-defined recovery plan outlining steps to restore disrupted processes is essential. This plan should ensure a smooth transition back to normality with minimal impact on the business.
ADVANCE	Advance focuses on using the learnings from the disruption to strengthen the resilience of the supply chain in the long term. Companies assess the impact of the disruption on their vulnerabilities and identify areas for improvement. By proactively addressing identified weaknesses and implementing preventive actions.
TRANSPARENCY	Transparency is not a separate phase but emerges as a central theme running through them all. Transparency in communication is a crucial element throughout all phases of T-IRRA, fostering trust and collaboration with all stakeholders.

4.2.1 TRANSPARENCY

The T-IRRA model presents four key phases for building a resilient supply chain.

Transparency is not a separate phase but emerges as a central theme running through them all. It creates a crucial link between risk management and a more resilient supply chain. A professional with practical experience in the field wanted to explain it as communication instead, and also emphasizes that it is the most important factor in building a resilient supply chain (Interview 1, 2024).

Consumers prioritize transparency, they want to understand the origin of their products (PwC, 2023). They want to be involved in the manufacturing processes and be aware of their environmental impact. This demand goes beyond simple knowledge, customers demand a sense of control. A study shows that customers want to be informed about potential disruptions and be involved in finding solutions. Companies are aiming to become more agile, flexible, and customer-centric, which goes hand in hand with transparency. Clear and consistent communication with all stakeholders is therefore crucial during disruptions (McKinsey & Company, 2023). By keeping customers informed of delays and potential impacts, freight forwarders can minimize frustration and instead build trust (World Economic Forum, 2023). Open communication is suggested to enable collaborative problem solving, which can lead to disruptions being solved more effectively (Sun et al., 2021).

Transparency is also crucial for the identification of potential risks themselves. According to Interview 1 (2024), you need to communicate forward to make protection. By sharing data and insights across the supply chain network, freight forwarders can gain a more comprehensive understanding of vulnerabilities. It is important that information is shared quickly, and that the information shared is accurate in case of disruptions. Transparency enables quick decisions and collaboration with suppliers and customers to minimize impacts (PwC, 2023). Rebuilding trust and ensuring a smooth return to normal operations also requires clear communication between all stakeholders.

By keeping everyone informed of progress and recovery timelines, carriers can achieve this (McKinsey & Company, 2022). Finally, learning and evolving from past disruptions is crucial to building long-term resilience. Here, transparency enables extensive analysis after disruptions, helping companies identify areas for improvement and implement proactive actions to strengthen the supply chain for the future (McKinsey & Company, 2023).

In substance, transparency serves as the fundamental building block of a robust supply chain. By promoting open communication and collaboration at all stages of the T-IRRA model, freight forwarders can create a more resilient supply chain that can stand up to disruption and adapt to changing environments.

4.2.2 IDENTIFY

An efficient supply chain is crucial to the success of freight forwarders. Disruptions in the supply chain can lead to delays, cost increases and unsatisfied customers. Therefore, it is important for freight forwarders to proactively identify and manage potential disruptions. The identification phase is all about risk assessment and being able to identify the risks that can cause the most damage to the supply chain (Emrouznejad et al., 2023).

A strong risk management system is crucial for a resilient supply chain. Companies use advanced technical tools to always enable transparency, which is crucial for many freight forwarders. Raza et al. (2022) explains how advanced technology is being transformed and presented as IT delivery models. Market screening, continuous data collection and analysis, and preventive training are all critical activities to identify potential disruptions (Interview 2, 2024). Companies are using technology such as the Internet of Things (IoT) and Artificial Intelligence (AI) to handle and analyze big data. Big data forms the basis for powerful proactive analytics, providing real-time insights into supply chain progress. For example, the IoT helps constant monitoring of cargo management and operations within logistics centers. This enables proactive intervention to address potential problems such as accidents or bottlenecks before they escalate (Parola et al., 2020).

Early identification of risks is crucial to build a resilient supply chain. A leading freight forwarding company uses a digital tool that allows different actors in the supply chain to report incidents (Interview 1, 2024). This information is then filtered and analyzed based on its relevance to a specific supply chain network. The supplier then conducts a thorough review to assess potential risks and collaborates with relevant suppliers to evaluate the potential impact of identified threats. Based on this collaborative assessment, proactive measures are implemented to mitigate potential disruptions. These measures may include developing emergency plans or exploring alternative sourcing options.

4.2.3 RESPOND

Immediate actions after a disruption is crucial. How to respond and what decisions taken at this point can significantly influence the duration of the problem, potentially minimizing it from hours to weeks (Interview 1, 2024). A leading freight forwarder emphasizes the importance of proactivity. One such crucial decision is to prioritize shipments. During an disruption, resources may be limited and not all deliveries can be completed. A logistics provider must determine which shipments are most sensitive to time and then prioritize them thereafter. Proactive implementation of a protection plan is crucial to manage disruptions according to one of the respondents (Interview 1, 2024). The plan may include speeding up deliveries of materials or increasing demand from suppliers to build up a buffer. This collaboration with suppliers helps to minimize the impact of disruptions while avoiding unnecessary inventory cost increases.

Jacobsson et al. (2020) explains the importance of supply chain execution applications when unforeseen events occur. It is essential that those affected by the disruption have the ability to exchange information with each other and have real time communication. Due to transparency the customer can see in real time when a disruption occurs. A leading logistics operator (Interview 1, 2024) emphasizes the importance of clear and consistent communication with customers throughout the disruption. Keeping customers informed minimizes frustration and builds trust during challenging situations. Another effective tool to respond when supply chain disruptions occur is to create flexibility. Flexibility can be defined as the ability to adapt to unexpected situations and respond quickly to changes in the supply chain (Stevenson & Spring, 2007). By building flexibility into its supply chain, a company can reduce the impact of disruptions and ensure a more robust and resilient operation.

Effective response to disruptions also depends on their nature and the elements affected. The key strategy lies in establishing alternatives according to Interview 2 (2024). For blockages, redirection is necessary. Supplier problems require sourcing from alternative suppliers. Port closures require the use of alternative ports. In addition, buffers, stocks, time and space are crucial to mitigate delays.

4.2.4 RECOVERY

A resilient supply chain can reduce the duration of a supply chain disruption and more effectively reduce the impact. The main goal in the recover-phase is to be able to return to the original state of the supply chain after a disruption. Strategies and frameworks like T-IRRA could help freight forwarder companies recover from a disruption, reducing the uncertainty and complexity that could follow from an interference (Scholten et al. 2014). Collaboration, which is frequently mentioned in connection to supply chain resilience, is therefore considered to be a crucial element to mitigate the disruption (Tukamuhabwa et al., 2015). Despite the phase being beyond the company's main prioritization, the importance of collaboration, in the form of sharing essential information to customers during the recovery phase, is well underlined. This is exemplified by one respondent as "by continuing with support to the customer when recovering, additionally through all the phases, the relationship only strengthens" (Interview 1, 2024).

Knowledge management is another element worth mentioning in the recovery phase as well as in the advance phase. It is the ability to learn from a disruption to develop better solutions and plans for future ones (Han et al., 2020). Together with risk awareness, the two elements are essential to achieve recovery while maintaining normal operations, in line with the function of supply chain resilience (Scholten et al. 2014). Other elements include visibility, the ability to view the supply chain in a clear way. Identifying vulnerable suppliers for preventing a disruption's negative effect on the supply chain. Both visibility and collaboration are key elements for the Risk Management team, when reviewing supply chain resilience according to one of the respondents (Interview 1, 2024).

Identifying risks, with help of using an advanced technology tool, allows one to get an overview of the potential threats to interrupt their supply chains. Finally contingency planning, which includes practices to help mapping the supply chain's vulnerabilities, to avoid or control the potential risk (Petit et al., 2010), is another element served to help a company build resilience in the recover-phase.

4.2.5 ADVANCE

When implementing supply chain resilience, advancing from disruptions is the phase of opportunities and evaluation of how to improve strategies according to one of the respondents (Interview 2, 2024). Advance in T-IRRA, concerns elements such as collecting experience, knowledge management and also underlines the contingency plan as a suitable tool. Chen et al. (2004) highlights the importance of evaluation post disruption. The strategies and actions made after a supply chain disruption can be crucial to avoid further similar events from occurring again. Once again, collaboration is also important in advancing. Freight forwarder companies would benefit from collaboration in their solutions but also learn from solutions and create future contingency plans for the whole supply chain (Interview 2, 2024). Advance is an opportunity to review the different actions that were made to mitigate the disruption and even continue to create supply chain resilience further. Strengthening the collection of savings, learnings and experience from a disruption is crucial, as the knowledge and experience needs to be spread across the organization for future advancement (Interview 2, 2024). One of the respondents stressed that a review of the disruption outcome is essential (Interview 1, 2024). To review the actions that were made during this phase and learn from them is beneficial to progress for upcoming disruptions. From a freight forwarder company's point of view, communication and sharing the important information to the customer, could benefit both parties as it's a sign of openness and understanding which have proved to build stronger relationships (Interview 1, 2024). One could also connect the relationship between the identify- and advance phase, as the learnings from managing a disruption could potentially be used to easier identify upcoming threats.

5. DISCUSSION

The study underlines a growing importance of customer engagement in supply chain resilience, as highlighted in interview 1. Customers are increasingly involved in the operational work of the supply chain and are eager to contribute to disruption preparedness, planning and decision-making. This points to a shift in thinking whereby shippers need to adopt a more collaborative approach, leveraging customer insights to tailor response phase and effectively solve disruptions. The findings on the increasing importance of customer engagement and collaboration in supply chain resilience provides insight into the strategic transformation in supply chain management. This focus on collaboration does not only reflect a response to today's increased complexity and vulnerability of global supply chains, but also a shift towards a more open and adaptive business model. But it is important to underline that more assessments of the role of freight forwarders in connection to customer engagement are needed to verify this trend and to identify if companies that successfully integrate customer insights into their business will be better prepared to deal with future challenges.

Transparent communication emerges as a common theme throughout our analysis and is reflected in the literature (World Economic Forum, 2023; PwC, 2023; McKinsey & Company, 2023). The findings highlight the central role of transparent communication in fostering trust, collaboration and effective problem-solving in all phases of the T-IRRA model. By keeping stakeholders informed and engaged, freight forwarders can not only mitigate frustration but also improve their ability to proactively manage disruptions.

The integration of advanced technologies also emerges as an important factor in supply chain resilience for freight forwarders. Findings underline the transformative and impactful role of technologies such as IoT and AI in improving visibility, predictive analytics, and real-time decision-making (Parola et al., 2020; Raza et al., 2022). This is particularly important at a time when the industry is facing increasing complexity and uncertainty. Technology can be seen as a key to building a more resilient supply chain. Rather than simply speeding up transit times, these technologies empower companies to proactively identify risks, predict disruptions and efficiently respond.

Arguably, the deployment of advanced technologies within supply chains also has a significant environmental impact, as the addressed strategies can reduce fuel consumption and consequently carbon emissions. However, the footprint of producing and disposing the technical hardware must also be considered.

Technology plays a dual role in society by both increasing transparency and requiring robust data protection measures. On the one hand, the increased visibility and real-time insights provided by technologies improve decision-making and operational transparency, contributing to greater supply chain resilience. On the other hand, the integration of such technologies introduces the need for significant investments in cybersecurity to protect sensitive data, creating a complex balance between transparency and security. The need for transparency to improve efficiency and resilience coexists with the necessity to protect data, illustrating the nuanced role of technology in modern supply chains. Therefore, despite the challenges, we see the role of technology as crucial to increasing the resilience and efficiency of the industry in the long term.

Further, something that is central to the concept of supply chain resilience is learning and continuous improvement. Our study highlights the importance of post-disruption evaluation (Chen et al., 2004), knowledge management (Han et al., 2020) and preparedness planning (Pettit et al., 2010) in strengthening the resilience of freight forwarding operations. By systematically analyzing disruptions, identifying their underlying causes and spreading lessons learned throughout the organization, firms can improve their resilience to future shocks by improving their strategies. This is crucial to face today's complex and changing market conditions and to ensure the long-term success and sustainability of the company.

5.1 METHOD DISCUSSION

A literature review was used to identify and analyze the data in a systematic way. This method helped to organize and categorize data and it helped us to understand repeated patterns and themes. The method was used to explore the concept of supply chain resilience. However, it is important to recognize that while a literature review offers comprehensive insights, it also has limitations. One such limitation is the risk of bias in the selection and of sources, which can affect the findings and conclusions of the review.

Despite these limitations, the literature review served as a fundamental step in the research process, providing a comprehensive understanding of the concept of supply chain resilience. Through the analysis of secondary sources, insights were gained that then formed the basis for the development of the T-IRRA model.

To develop the model, a model approach was applied. It was of importance that the model felt relevant and applicable to the people and companies involved in the report, which carefully was considered. This method allowed the exploration of the complexity and variety of the concept of supply chain resilience in more detail. A framework that made it easier to analyze what had been planned and the aspects of what supply chain resilience means. In addition, it is important to take a critical stance to the methodology and results. While striving to develop a model that accurately represented the concept of supply chain resilience, recognizing the possibility of errors or oversights is crucial.

During the method consideration process, the possibility of conducting a systematic literature review was evaluated. This method, which involves a more structured and comprehensive approach to reviewing literature, could potentially have minimized bias and provided a more in-depth understanding of existing research. In reflection, a systematic literature review may have been a more robust approach which could have strengthened the findings

6. CONCLUSION

The report explores strategies of how freight forwarders could handle supply chain disruptions and build supply chain resilience. The presented T-IRRA model could serve as a framework for freight forwarding companies, with the aim to sustain supply chain resilience throughout all phases of a supply chain disruptions. The two phases: “Identify” and “Respond” connect to the first research question, proactively identifying and managing potential disruptions within the supply chain. The phase Identify summarizes the importance of a strong risk management and the usage of advanced technology, while phase Respond underlines building flexibility in options and clear and consistent communication. By using suitable strategies and with the help of the model framework, freight forwarders or other actors concerned around the concept can proactively mitigate these disruptions to ensure operational progression and efficiency. On the other hand, “Recover” and “Advance” are linked to the second research question, how companies efficiently process their actions to recover from a supply chain disruption and minimize the overall impact. As the phase Recover covers the ability to return to the original state of the supply chain, collaboration in the form of sharing information throughout the whole process is mentioned to be vital within this stage. In phase Advance the experience of learning from the disruption by using several tools and strategies. Knowledge management is mentioned combined with evaluation, reviewing and collaboration once again. While the T-IRRA model includes different elements for each stage of handling a supply chain disruption, served with the goal of maintaining supply chain resilience especially for freight forwarding companies, it’s important to understand that supply chain resilience is not an achievement but an ongoing journey.

7. RECOMMENDATIONS FOR FURTHER RESEARCH

In future research, there could be an aim to explore whether a company's efforts to strengthen its supply chain resilience, affect its sustainability performance. Additionally analyzing supply chain resilience from a cost perspective or investigate if companies would invest more in supply chain risk management to gain greater supply chain resilience.

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APPENDIX 1

Interview 1 - Questions focusing on Supply Chain Resilience

Part 1 - Introduction

1. What does supply chain resilience mean for (company's name)? And how would (company's name) you define a supply chain disruption?
2. What type of disruptions is most common for (company's name)?
3. Which mode of transport would you consider is "most vulnerable" for disruptions for (company's name)?
4. Could you identify any recognizable pattern between disruption and the type of cargo?

Part 2 - Brief introduction to our T-IRRA model:

We have concluded the following supply chain resilience model through literature research and concluded it into four different phases as presented below. Keep in mind transparent communication is not considered a phase, as it's included in every area below:

Identifying - *This phase focuses on anticipating potential disruptions before they occur.*

Responding - *This phase involves taking immediate action when a disruption hits.*

Recovering - *This phase focuses on restoring normalcy to your operations after a disruption.*

Advancing - *This final phase focuses on learning from disruptions to strengthen your supply chain resilience for the future.*

1. How do (company's name) work to identify potential disruptions?
2. How do (company's name) minimize the consequences after a disruption?
3. What does (company's name) do to recover from a disruption?
4. What actions is (company's name) taking to benefit from the effects of the disruption and strengthen its supply chain in the long term?

APPENDIX 2

Interview 2 - Questions focusing on Supply Chain Resilience

Part 1 - Introduction

1. What does the concept of supply chain resilience mean to you?
2. Which mode of transport would you consider is most vulnerable for disruptions?

Part 2 - Brief introduction to our T-IRRA model:

We have concluded the following supply chain resilience model through literature research and concluded it into four different phases as presented below. Keep in mind transparent communication is not considered a phase, as it's included in every area below:

Identifying - *This phase focuses on anticipating potential disruptions before they occur.*

Responding - *This phase involves taking immediate action when a disruption hits.*

Recovering - *This phase focuses on restoring normalcy to your operations after a disruption.*

Advancing - *This final phase focuses on learning from disruptions to strengthen your supply chain resilience for the future.*

1. Why do you think the identifying phase is important within Supply Chain Resilience?
2. Would you consider any actions more important than others in this phase?
3. From your experience, what are the direct actions companies need to take after a disruption has occurred?
4. What do you think is a company's main goal when recovering from a disruption?
5. In your opinion, how can companies leverage disruptions as opportunities to learn and strengthen their supply chains in the long term?

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