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TITLE

Management of supply chain resilience and its development

Master thesis

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INTRODUCTION

Recent shocks, such as the Russia-Ukraine war, the COVID-19 pandemic, the energy crisis, geopolitical instability, and other disruptions, have exposed the fragility of global supply chains. These disruptions have resulted in a shortage of raw materials, a lack of components, and uncontrolled price volatility.

According to the Global Value Chain Barometer, disruptions in supply chains related to climate change increased by 146% compared to the previous year. Similarly, as the World Economic Forum in Davos 2023 reported, geopolitical tensions have caused a 110% increase in disruptions.

Additionally, the growth of the cyberattacks (Ghadge et al, 2019) the lasting effects of the Covid-19 pandemic (Herold et al., 2021), and the economic instability (Jüttner & Maklan, 2011) have contributed to disruptions in the global supply chains. Therefore, the Global Supply Chain Barometer report (2023) emphasizes the importance of developing a proactive system with a high level of resilience that enables supply chains to react quickly to emerging disruptions, ensuring the long-term stability of supply chains and in order to comprehend how businesses strengthen their operations against these challenges, it is crucial to grasp the essence of a supply chain that is described as a network of materials, information, and services (Chen & Paulraj, 2004). They include all entities involved in fulfilling the customers' needs regarding products and services, such as manufacturers, suppliers, clients, wholesalers, retailers, warehouses, and transporters (Felea & Alb, 2013). The supply chain encompasses all functions in receiving and fulfilling a customer request, including new product development, marketing, operations, distribution, finance, and customer service (Chopra & Meindl, 2007, p. 3). So, it can be stated that the supply chain’s complexity varies depending on the number of entities involved. Also, if a crisis or disruption in one part of the supply chain happens, it can spread at lightning speed and collapse the entire supply chain **(**Tukamuhabwa et al., 2015)**.**

All the reasons above underscore the need for comprehensive supply chain resilience management and its role to respond effectively to challenges and adapt to uncertainties more efficiently.

During the examination of studies on the management of supply chain resilience and its development, it was observed that multiple researchers have confirmed that there is a lack of a unified approach to what a resilient supply chain is (Christopher, 2011; Christopher & Peck, 2004; Kamalahmadi & Parast, 2016; Ponis & Koronis, 2012) and have incorporated the concept of resilience into supply chain management from various perspectives.

It is noted that the concept of resilience was initially developed in other fields, such as psychology (Rees et al., 2015), sociology (Hempel & Lorenz, 2014), and ecology (Holling, 1973). Nevertheless, resilience development in the context of supply chains has been gaining attention among various scholars in the business management (Irfan et al., 2022; Munir et al., 2022; Song et al., 2022). However, studies of the scientific literature have revealed that there are various approaches to the conceptualization of this phenomenon.

(Joshi & Luong, 2022) recently identified that most scholars have concentrated only on reactive aspects of supply chain management when dealing with resilience in the face of uncertain disturbances, while other factors like preparedness and growth have been less strongly emphasized in their discussions. So if, on the one hand, some authors discussed reactive aspects (Joshi & Luong, 2022; Thun et al., 2011; Tukamuhabwa et al., 2015) other authors (Sheffi & Jr, 2005) (Agrawal & Jain, 2021; Sadeghi et al., 2021; Sarkar et al., 2022; Shishodia et al., 2021; Tanuputri & Bai, 2023; Vargas & González, 2016) emphasize the importance of managing supply chain resilience proactively, preventively, adaptively, redundantly, collaboratively, and through other approaches during crises. Therefore, proper supply chain resilience models are necessary to clarify the different approaches to managing resilience.

Emphasizing the significance and importance of supply chain resilience to achieve long-term stability and prosperity in companies and how important it is for these entities to prioritize investing in it, **the research problem** was identified, and the main research question has been established:

Research problem- What methodological approaches can be employed to manage supply chain resilience, enhancing its capacity to cope with uncertainties within different companies?

The research aims to identify the theoretical interpretations that form the basis of the concept of a resilient supply chain, explore the methodologies that can be applied to manage and strengthen resilience in supply chains, and propose a model that identifies the strategies to enhance **resilience in the supply chains.**

Additionally, the objectives of the research have been formulated:

Objective 1: Identify theoretical approaches and frameworks that support the conceptualization and enhancement of resilient supply chains.

Objective 2: Introduce a theoretical supply chain resilience development model justifying its conceptual structure.

Objective 3: Develop a research methodology for managing supply chain resilience in companies to enhance it.

Objective 4: Conduct an empirical study to explore the strategies for supply chain resilience development in the logistics companies.

Objective 5: Drawing from theoretical and empirical findings, propose the strategies for developing supply chain resilience as a means to cope with adversity.

Scientific results of the study

Supply chain resilience has become increasingly important in recent years as a response to the growing number of disruptions in supply chains. However, researchers and practitioners have identified gaps in previous research, highlighting a need for comprehensive and well-established models for managing and developing supply chains to enhance resilience. This research gap will be addressed and filled in to equip supply chains for future challenges better.

The originality **and novelty of the research topic** are based on an attempt to validate the benefits of resilience to reduce the impact of crises on supply chains by presenting the latest scientific literature based on the developed methodological approach for the management and development of resilient supply chains.

The object of the study: Models and approaches for supply chain resilience development and management.

Research methods: Qualitative research methods, such as expert study, semi-structured interviews, and content analysis, are chosen for this study. This choice was made to delve deeply into the complexities of supply chain disruptions and resilience; this approach enables a comprehensive understanding of the contextual nuances.

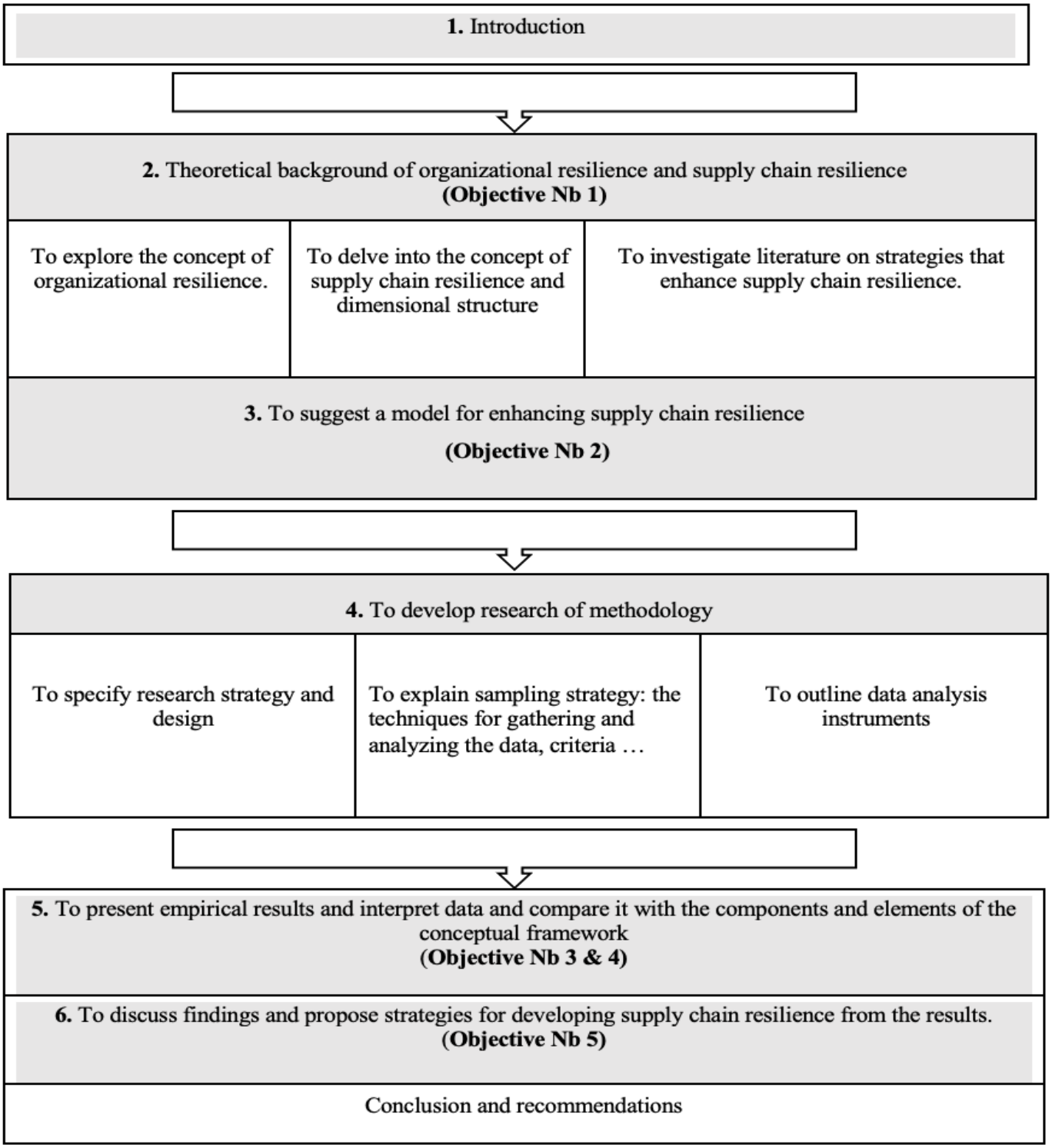
Scope: The study will focus on the development of comprehensive methodological approaches for managing supply chain resilience, and it will stress on drawing a model of conceptualization of a resilient supply chain, based on a qualitative approach related to the structure and analysis of the content. Additionally, the interviews will be conducted in three different countries.

Limitations: The study's limitation arises from the absence of a quantitative survey involving a larger sample of employees from the selected companies. Conducting such a survey could have offered more extensive outcome data and insights that could be applied to a larger group of people.

Theoretical implications: This study reveals new critical strategies in supply chain resilience, supplementing those previously mentioned in the literature. Furthermore, the proposed framework not only contributes to the existing theories but also introduces a novel concept of supply chain resilience and its development. It also introduces a model that outlines when and what strategy to apply in case of a disruption.

Practical implications: The findings of this study can be used by practitioners and policymakers seeking an in-depth understanding of the concept of supply chain resilience, including its strategies, dimensions, concepts, phases, and categories based on recent articles and qualitative research; it offers a reach source of information to conduct further investigation related topic. Additionally, it provides valuable insights for companies offering actionable guidance in navigating such challenges in supply chain operations.

Figure 1: Structure of the thesis



Source: Autor's creation

1 LITERATURE REVIEW

The application of the literature review in this research follows a strict methodological structure. Still, it is more flexible in selecting relevant scientific sources that will serve as a basis for deepening the research subject. The search for scientific sources was carried out by gathering a wide range of articles from various sources such as Emerald, EBSCOhost, Google Scholar, and Taylor & Francis Online using the key search terms: supply chain resilience, resilience, management of supply chain resilience, resilient supply chain.

After the retrieval of the articles, careful evaluation was applied to each of the papers to ensure the selected articles were relevant to the research problem. Both conceptual and empirical articles were considered suitable for this research since most of them align with the study's objectives and scope. Also, additional sources were identified while examining the reference lists of the selected articles, enabling expansion of the potential list of articles. Finally, almost eighty articles were retrieved for further analysis and synthesis. The articles were organized with Zotero's help.

1.1 The concept of supply chain

The supply chain "consists of all parties involved, directly or indirectly, in fulfilling a customer request" (Chopra & Meindl, 2007, p. 3); it encompasses various participants such as manufacturers, suppliers, retailers, wholesalers, transporters, warehouses, and even the end final customers, it is the entire process that a product takes from its initial raw materials to its final form, involving all the stages within the business to business market (Felea & Albăstroiu, 2013). the company Nestlé, a Swiss multinational food and beverage company, sources raw materials and ingredients from over 5 million farmers in rural areas to produce a range of products in the food industry [1]. The company's supply chain involves transporting the raw materials to Nestlé's manufacturing facilities, where they are processed to create the final product. Quality control is also carried out to ensure product safety and compliance with requirements. After the manufacturing phase, the products are distributed to Nestlé's warehouses, where inventories are managed via advanced technologies and data analysis to meet the customers' preferences, and deliveries are made to retailers, including stores, supermarkets, and other customers. Additionally, innovation is one of the main stages of Nestle's supply chain since it invests in research and development to address people's diverse

[1] https://www.nestleusa.com/csv/responsible-sourcing

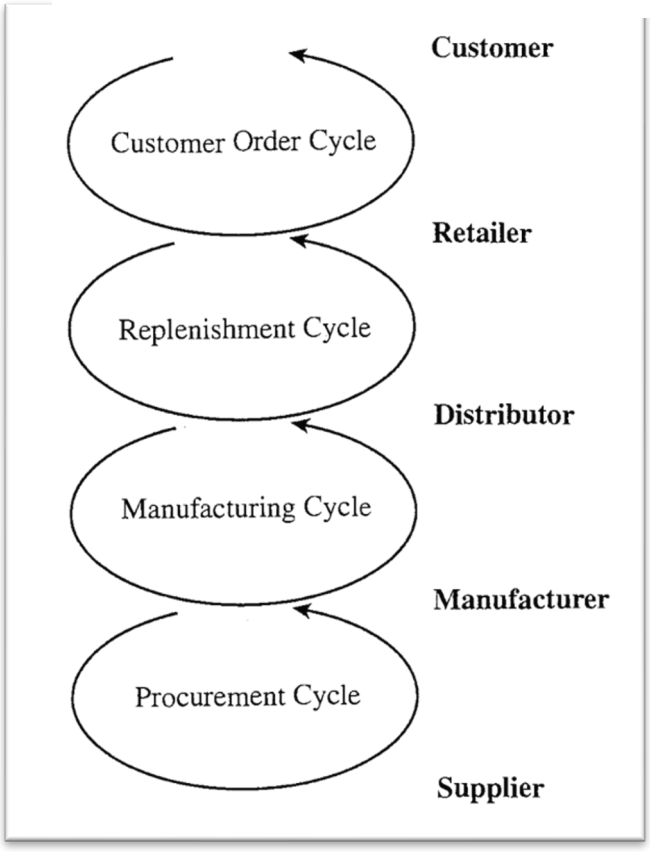
evolving needs. So, the supply chain is about the entire process that a product takes from raw material to the end customer.

The authors (Chopra & Meindl, 2007, p. 11) have discussed how the supply chain operates in four different cycles with five parties involved, as illustrated in Figure 2, starting from the customer order cycle to replenishment (inventory is restocked), manufacturing, and procurement cycle (obtaining goods and services), these cycles happen between different stages of the supply chain however the supply chain operations depend on the nature of the business. Also, not all supply chains have all four cycles separated.

For instance, a grocery store has all four cycles separately, i.e., the stages can be distinguished for each cycle, while Dell's direct sales, being the manufacturer of their computers, may bypass some of these cycles.

In conclusion, it is essential to understand how the supply chain works to fit the strategies within specific operations, which leads to effectiveness and efficiency.

Figure 2 : Supply chain process stages



Source :Chopra & Meindl, 2007, p. 11

1.2 The concept of organizational resilience

Since supply chain resilience and organizational resilience are interconnected and closely related concepts (Fayezi & Ghaderi, 2021), it was necessary to demonstrate first the context of organizational resilience and its relationship with supply chain resilience.

Nowadays, there are multiple types of disruptions ranging from wars, terrorism, natural disasters, and socio-political changes; these challenges prompt organizations to seek to be capable of handling and minimizing the risk of any potential threats; consequently, the theory of resilience has become a principal guidance. Resilience has been explored in different disciplines and was discussed from various perspectives, such as psychology, ecology, economy, and engineering (science), and some authors have considered the concept of resilience multi-dimensional and interdisciplinary. (Ponomarov & Holcomb, 2009; Ponis & Koronis, 2012). The fact that resilience have been adapted and applied in different fields, and have been studied in years by multiple researchers, it was challenging to discover who was the first to define it since notable contributors in other areas of study have played a significant role to construct and form the concept of resilience, hence Holling C.S was one of the earliest authors who used the term resilience in the ecological context and he defined it as a "measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973, p. 14) it's a characteristic displayed by individuals or organizations, it's defined as the capability to absorb effects of shocks (de Bruijn et al., 2020), maintain and even improve the performance in the face of challenges and disruptions within the organization like fast changes, ineffective leadership, production fluctuations or high performance pressure, or outside the organization like competition or high demand from the stakeholders, (Sutcliffe & Vogus, n.d.) , it can be also defined as the ability to recover and bounce back while enduring unfavorable conditions (Bhamra et al., 2011) and not necessary to the same situation as before the sudden shock(Chroust et al., 2016).

Three categories of resilience can be found: engineering resilience, systems resilience, and complex adaptive systems (Martin-Breen & Anderies, 2021; Botjes, 2020 ; Holling, 1973).

- **Engineering resilience:** aims to bounce back rapidly from disruption and return to its normal state without changing or being irreparably damaged (Martin-Breen & Anderies, 2021, p .5.) *for example,* when designing a bridge, it is necessary to bear significant loads and withstand weather conditions such as storms, so the

bridge absorb the shock and return to its initial condition, here the stress does not affect the value as illustrated in Figure 3, also engineering resilience can be measured by "the resistance, elasticity, and stability" (Martin-Breen & Anderies, 2021, p 44.)

- **Systems resilience:** Known as well as robustness in economics, it is the capacity of a system to absorb the shock while going through transitions and without losing "the same function, structure, identity, and feedback" (Botjes, 2020, p. 9). *for example*, the dynamic character of a government is considered as a system including communities and individuals, so in case of changes over time in the laws or regulations, the resilience of individuals can be affected because it is not only about the individuals but also about the community they belong to, even small changes can have an impact on the system's response to sudden crises, as shown in Figure 3 (Martin-Breen & Anderies, 2021., p. 7).here the stress does not affect value.
- **Complex adaptive system (CAS):** "the ability to withstand, recover from, and reorganize in response to crises. Function is maintained, but system structure may not be" (Martin-Breen & Anderies,2021, p. 7); the difference between complex adaptive systems and systems resilience is the adaptive capacity and ability to develop novel operational systems and new systematic relationships. Here the stress has some effect on value. as illustrated in Figure 3.

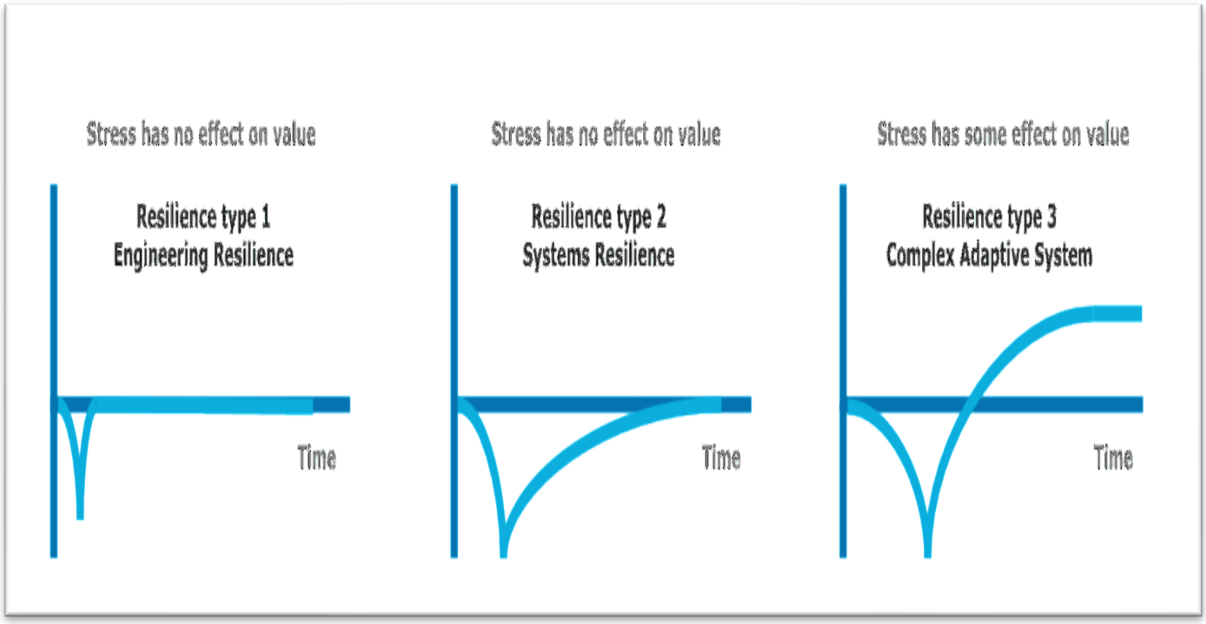
To proceed with the research, it was crucial to delve deeper into why complex adaptive systems have a more significant impact on value compared to engineering and systems resilience. It is worth noting that numerous authors have mentioned the benefits of the complex adaptive system approach when discussing supply chain resilience, as well as the fact that organizational resilience can be achieved by complex adaptive systems approach (Adobor, 2020; Adobor & McMullen, 2018; Botjes, 2020; Dahlberg, 2015; Fayezi & Ghaderi, 2021; Tukamuhabwa et al., 2015; Yao & Fabbe-Costes, 2018)

To answer this question, (Botjes, 2020) has mentioned that this results from the fact that a complex adaptive system has two features, a dynamic nature and an adaptive capability meaning that the components of the complex system have the capacity to adapt and change or even evolve when responding to the changes, so it can be stated that the system, in this case, benefits from the disorder and generate opportunities from the disruption, further more

complex adaptive system is about creating more diversity i.e having different solutions to cope with the disruption and contribute to the success of the organization, so stress might have positive effect on value while the function is maintained when the system structure might change (Martin-Breen & Anderies, 2011)

On the other hand, engineering resilience and robustness break down when the limits of stress are exceeded because they focus more on stability, which is essential for organizations, except that they don't lead to the same level of value as in complex adaptive systems.

Figure 3: Three sub-types of resilience



Source : (Botjes, 2020, p. 10)

Among the influential authors in the field of organizational resilience (Sutcliffe & Vogus, 2003) have highlighted the concept of resilience from the organization perspective to confirm that resilience have been used to refer as "the ability to recover or bounce back from untoward events"(Sutcliffe & Vogus, 2003 p. 3) also it was defined as the organization's ability to stay stable, absorb , recover, adapt, ,transform and grow in the face of crises (Lengnick-Hall et al., 2011; Sawyerr & Harrison, 2019 ;Bartuseviciene et al., 2023; Duchek, 2020) furthermore resilient organizations display the capacity to adjust adapt and cope with adversity through flexible organizational structures and strategies in the face of challenges (Sutcliffe & Vogus, 2003.). in the same way (Yao & Fabbe-Costes, 2018) have mentioned that the concept of resilience embraces a range of individual and collective attitudes and behaviors at different

levels: individual, organizational, inter-organizational, system. It centers the capabilities to absorb shocks, bounce back and respond to shocks, learn from the experience, and anticipate future shocks for a continuously developing process.

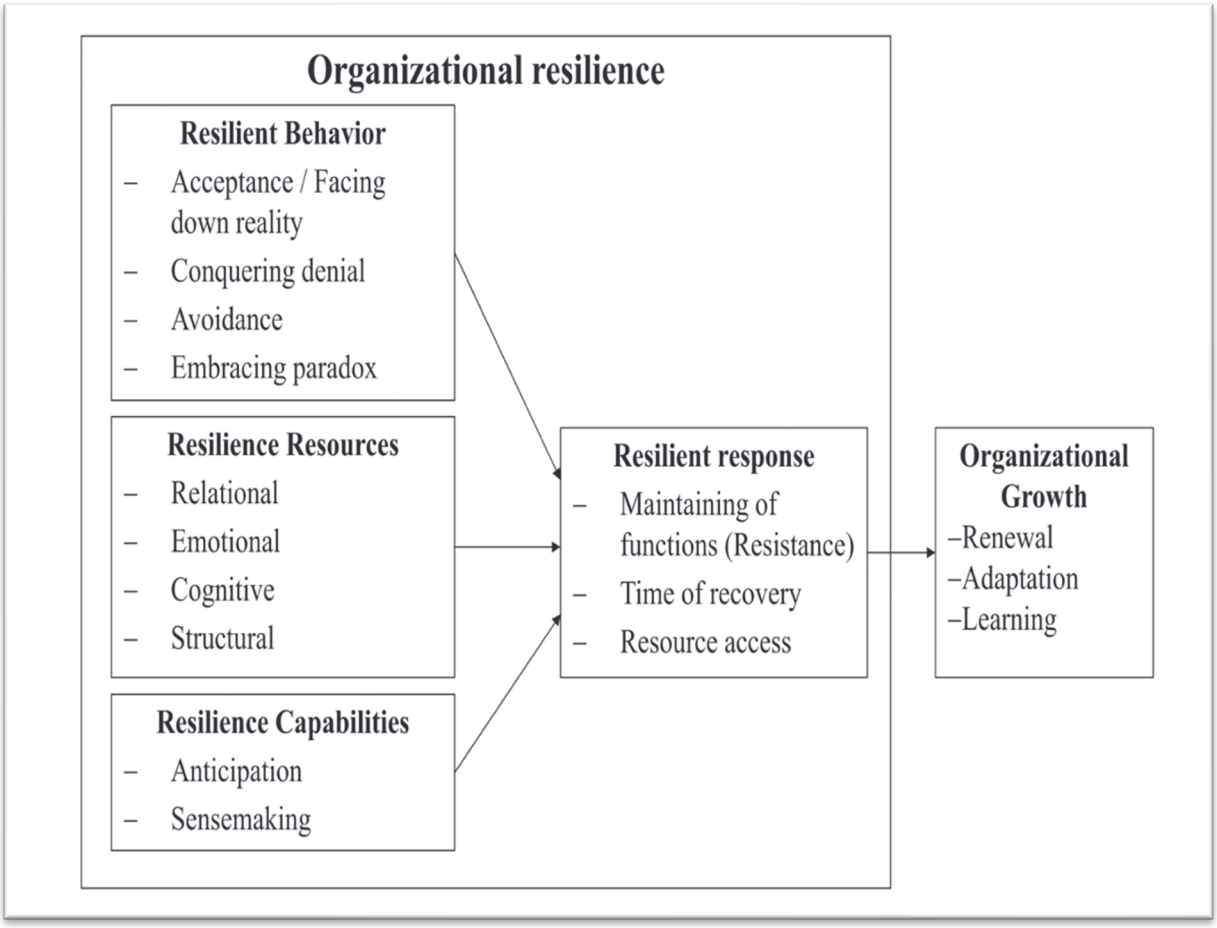
So, while there are multiple definitions of organizational resilience, it cannot be neglected that there is no universal and shared understanding of the concept Field (Duchek, 2020); as a result, it remains vague on what organizational resilience is precisely. and how it can be achieved.

To address this issue, an attempt was made to explore the framework proposed by (Hillmann & Guenther, 2021) to understand and measure organizational resilience. For this purpose, (Hillmann & Guenther, 2021) suggested a combination of three factors: behavior, resources, and capabilities as described in Figure 4, in order to determine how organizations can bounce back from disruptions and challenges to return their previous level of performance, to respond and grow stronger. In order to do this, it's essential to break down organizational resilience into smaller parts or dimensions, which helps to build a better understanding of what it means. For example, it involves understanding how organizations behave when facing a disruption (e.g. deny, accept, avoid), what resources they have (e.g. emotional, cognitive, structural, relational), and what kind of capabilities they possess (e.g. decision-making, anticipation, knowledge management).

Therefore, the comprehension of these elements will help organizations to respond to challenges by maintaining their functions and resisting to recover quickly, and in the end, the goal remains the same that the organization can adapt, grow, and learn from the lessons.

Nevertheless, (Biggs et al., 2012; Rees et al., 2015) confirmed that in the workplace, individual and organizational resilience are critical factors that determine success. The resources that contribute to resilience are also crucial and can be categorized into four main categories: relational, cognitive, emotional, and structural. Additionally, behavioral resilience, which includes acceptance, denial, avoidance, and embracing paradox. It is essential to note that some individuals are more resilient than others, handling stress and challenges more positively. However, some groups may struggle and exhibit negative emotions and behaviors such as anxiety, burnout, or depression. Therefore, it is crucial to prioritize resilience-building activities to enhance productivity and success in the workplace.

Figure 4 : Conceptual integrative model



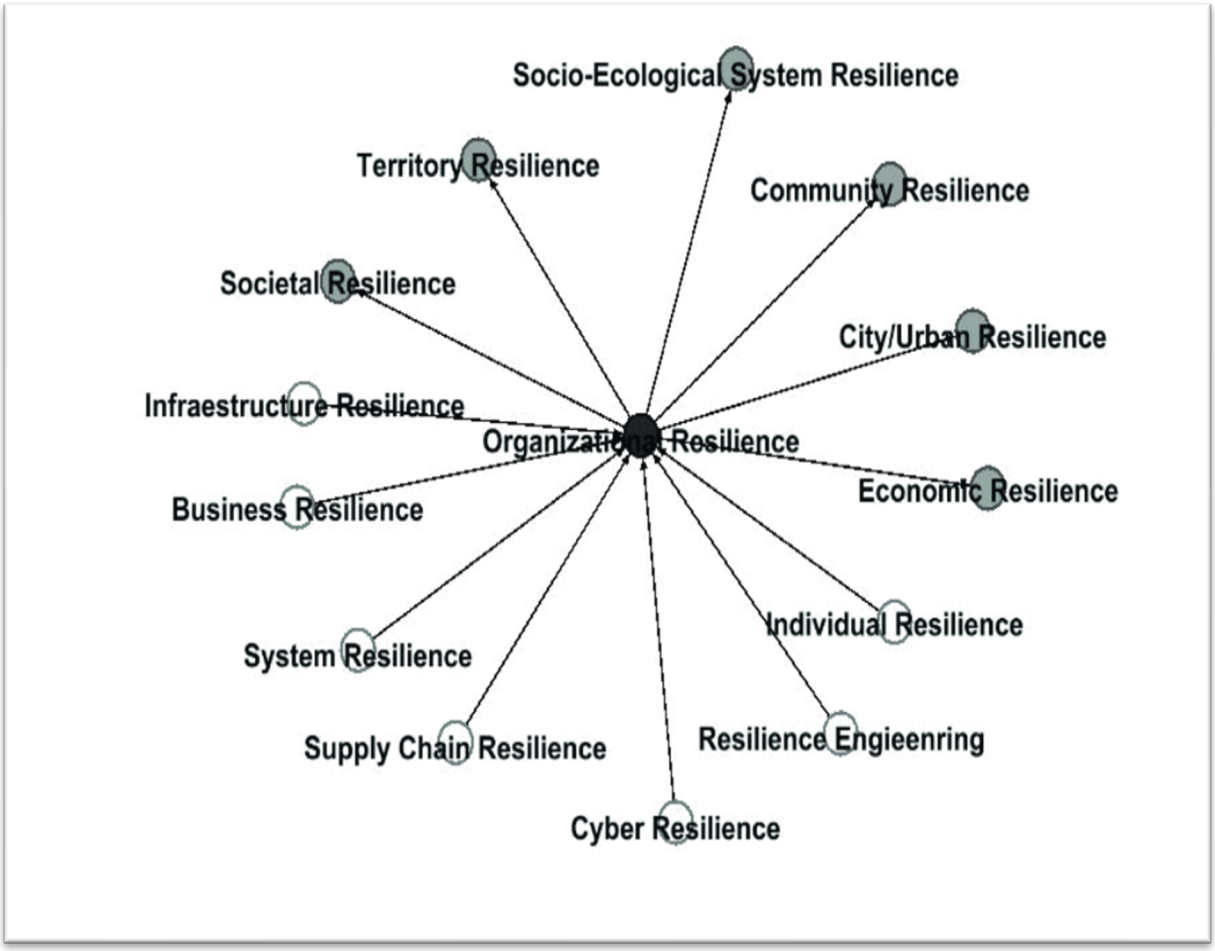
Source : (Hillmann & Guenther, 2021, p. 32)

Therefore, and as reviewed in Figure 4, it can be assumed that individual resilience can have a massive impact on organizational resilience, If individuals show higher levels of resilience, it might contribute to the overall resilience of an organization to withstand disruptions and adapt to challenges. However, does only individual resilience influence and impact organizational resilience?

The authors (Ruiz-Martin et al., 2018) have already responded to this question, as illustrated in Figure 5, confirming that on one hand organizational resilience can affect and influence socio-ecological system, community, territory, societal, city-urban, and economic resilience, and on the other hand the influence on organizational resilience is not limited to individual resilience, but also engineering, systems resilience, cyber resilience that is defined as "the ability to prepare for an attack and to keep operating and recover quickly" (Punt et al., 2023

p.420), business resilience outlined as an organization's capacity to swiftly adjust to disturbances, maintaining continuous business activities, safeguarding the welfare of individuals, assets, and the overall brand reputation (Paul Kervin 2022), infrastructure resilience is described as “the ability to withstand, absorb, respond to and recover to the original state of emergencies (such as earthquake, fire, terrorist attack)” (Yang & Cheng, 2020, p . 776) and finally the organizational resilience can be affected and influenced by supply chain resilience that is the central goal of the research and which will be in-depth explained in the next part.

Figure 5: Relations between resilience concepts and organizational resilience



Source: (Ruiz-Martin et al., 2018, p. 12)

To sum up, resilience is a complex concept that includes different forms, such as engineering, systems, and complex adaptive systems. Out of these forms, complex adaptive systems are more impactful in terms of value due to their dynamic and adaptable nature. They are instrumental in achieving organizational resilience in supply chain scenarios.

Although the definition of organizational resilience is vague, it can still be based on a combination of factors such as behavior, resources, and capabilities. However, resources and behavior are individual resilience factors significantly impacting organizational resilience. However, organizational resilience is influenced and affected by individual resilience and extends to other forms, such as cyber, business, infrastructure, and supply chain resilience. It is important to note that organizational resilience isn't independent but significantly impacts socio-ecological systems, communities, territories, societies, urban environments, and economic landscapes. This interconnectedness highlights organizational resilience's broader influence and significance beyond its immediate boundaries.

1.3 The concept of Supply chain resilience

The idea of supply chain resilience has become increasingly important for companies that want to minimize disruptions and problems within their supply chains. Since the early 2000s, the world has faced various crises, including the Financial Crisis (2007-2008), the European Debt Crisis (2010-2014), the Arab Spring (2010-2012), the H1N1 Influenza Pandemic (2009), the COVID-19 Pandemic (2019-present), and the Russian-Ukrainian War (2021-present). These crises have highlighted the need for organizations to focus on supply chain resilience so that they can effectively respond to and recover from such challenging events.

Consequently, a lot of attention has been given to researching supply chain resilience. It appears that there is still a need for greater clarity, understanding, and conceptualization of the concept. According to (Ponomarov & Holcomb, 2009), multiple definitions have been explored in the extensive literature on the topic to identify common recurring elements. This process facilitates the creation of a common model for understanding the nature of resilience in different supply chains.

Multiple researchers; (Ponomarov & Holcomb, 2009 ; Piprani et al., 2020;Hussain et al., 2022); referred to supply chain resilience as the *adaptive capability* to *prepare* for unforeseen events, *respond* to disruptions, and *recover* from them while maintaining interrupted operations and control inside the supply chain. Hence, (Holgado & Niess, 2023) confirmed that most definitions in the earliest research were intensely focused on response during the event and recovery after the disruption, while preparation and growth via opportunities were only emphasized afterward. Though (Tukamuhabwa et al., 2015) stressed the fact that supply chain resilience can be assessed not only by preparation, adaptation, response, and recovery but also by post-event *growth* and earning a *competitive advantage* after the event.

(Christopher & Peck, 2004) also discussed supply chain resilience as the ability to *return to the original state* after being disturbed or even move to a more desirable one.

It's a *dynamic process* of directing efforts to help organizations stay out of the uncertain event and to initiate a quick, *efficient response* to minimize the adverse outcomes while *regaining stability* before the disruption occurs to adapt its operations to the new changed environment (Datta, 2017). Besides, it's considered a *restorative capability* (Sadeghi et al., 2021) since the primary goal of supply chain resilience remains to avoid the occurrence of critical disruptions and return to the original state.

Furthermore, Resilient supply chains have the power *to transform* after a disruption (Adobor & McMullen, 2018). *Anticipation* is also a crucial element that forms supply chain resilience, signifying the ability to proactively identify and prepare for challenges or disruptions (Gunasekaran et al., 2015, p. 6811). The Absorptive capability is critical for better supply chain resilience, signifying the capacity to absorb negative impacts and respond to unexpected changes while capitalizing on knowledge, either in the success or failure (Yao & Fabbe-Costes, 2018). These abilities are what distinguish the high-value performance of one organization from another.

The concepts explained earlier are valuable and share common gaps, but it was observed that most definitions lack actionable insights and relevance in the supply chain resilience (Adobor & McMullen, 2018; Christopher & Peck, 2004; Piprani et al., 2020), that means that they lack providing practical understanding, especially that sometimes authors provide definitions that are vague and open for different interpretations. For that and to align with objective number 2 of the research: 'introducing theoretical supply chain resilience development framework justifying its conceptual structure.' providing a new definition that is more suitable for the research question and that offers clarity and responds to the gaps identified earlier was necessary to advance the research and to incorporate relevant aspects.

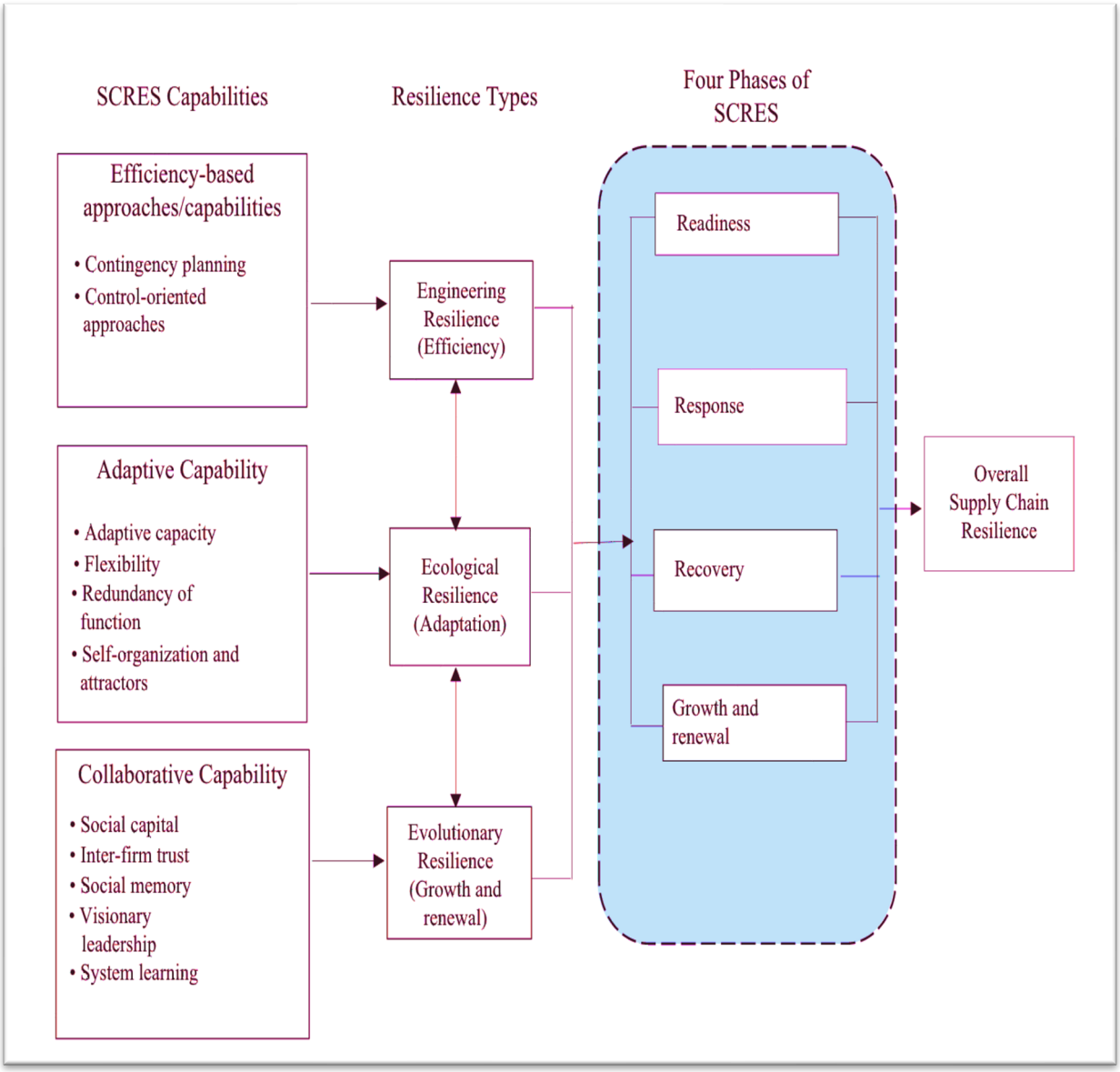
Author's own definition of supply chain resilience

Supply chain resilience refers to the organization's ability to proactively **anticipate** potential disruptions, **prepare for them** in advance, and minimize their adverse impacts, and once the disruptions occur, the organization should have a pre-established **response plan** in place to reactively respond. Afterward, the organization should **assess the lessons learned**, **adapt, recover, and re-structure itself after adversity to a new equilibrium** by making strategic changes to enhance resilience for the future and own the **competitive advantage** in the supply chain.

As was confirmed earlier, different authors approach the concept of supply chain resilience from different angles, and the fact that supply chain resilience has wide-ranging facets, but though some dominant stages and capabilities were repeated by multiple researchers, i.e., the phases and capabilities that describe the most supply chain resilience **(preparation, response, adaptation, and recovery)** and that's the other reason why they were mentioned as well in the proposed definition. Also, it was crucial to validate this new definition and to address the issue of these diverse aspects, so an effort was made to delve into the framework proposed by (Adobor & McMullen, 2018), as mentioned in Figure 6 that outlines four stages of **preparation, response, recovery, and growth,** as for **adaptability** it was cited as one of the capabilities

To understand the concept of supply chain resilience, it can be stated that these four critical stages or as other authors call them, capabilities (Ponomarov & Holcomb, 2009) (Piprani et al., 2020) (Hussain et al., 2022) form the essence of supply chain resilience. So, what are the precise definitions of these elements? and how can they develop supply chain resilience?

Figure 6 framework of supply chain resilience



Surce: (Adobor & McMullen, 2018, p. 1453)

Before starting the explanation of the framework illustrated in Figure 6 the discussion should be initiated from the fact that a resilient supply chain is considered as a complex adaptive system (Abbasi & Varga, 2022; Adobor & McMullen, 2018; Fayezi & Ghaderi, 2021; Tukamuhabwa et al., 2015) because firstly resilient supply chain has a **dynamic nature** (Tukamuhabwa et al., 2015) that arises from different factors, such as changing environments in the supply chain, which require adaptation to face challenges secondly, the components of the supply chain are interconnected; therefore, if one part of the supply chain collapses, the entire system will be affected (Tukamuhabwa et al., 2015) for example if a supplier delay the

transportation of raw materials the production , inventory , and customers deliveries will be delayed .thirdly in complex adaptive systems the **self-organization** is a must, for instance (Choi et al., 2001) suggests that in complex systems things are not guided and controlled by one or two elements instead, it's influenced by many different parts working together for the same goal, in supply chain, achieving success in any complex system or process often requires the collaboration of multiple parts working towards a common objective. For example, the process of validating a supplier involves numerous entities, including procurement, purchasing, and quality control, working in concert toward the shared goal of selecting the best possible supplier. Each of these components plays a crucial role in the overall process, utilizing their specific skills and expertise to ensure the supplier meets the required standards and specifications. By working together, these different parts of the supply chain can efficiently and effectively achieve their shared objective.

Therefore, it is clear that the characteristics of a resilient supply chain and traits of the complex adaptive system are common. That is why it can be stated that a supply chain is a complex adaptive system; for this reason, the authors (Adobor & McMullen, 2018) tried to develop the framework of supply chain resilience as illustrated in Figure 6 from a complex adaptive system perspective .to connect resilience to supply chain structure, in order to show the capacity of resilience to change across phases of supply chain development.

Resilience has multiple different types; the authors focused only on three types of resilience: engineering, ecological, and evolutionary or socio-ecological resilience.

Firstly, **engineering resilience,** as explained earlier by (Martin-Breen & Anderies, 2021,) refers to the ability of organizations to quickly bounce back from unexpected events and resume normal operations without any changes in their structure or function. According to (Hollnagel et al., 2006), it is an expression of the methods and principles that prevent challenges to safety systems resulting from instability. Additionally, three goals define resilience engineering, namely efficiency, constancy, and predictability, as identified by (Holling, 1973). These goals can only be achieved through capabilities and approaches based on efficiency, such as a contingency plan outlined as “an effective tool that involves developing responses in advance to manage disruptions that may impact the supply chain”, as suggested by (Adobor & McMullen, 2018, p. 1455).

The contingency strategies, for example, backup plant/subcontractor/sourcing and flexible sourcing to maintain production in case of a disruption, are necessary for the recovery of supply chain performance to return to the original state, as suggested by (Tan et al., 2020, p. 5177). Furthermore, supply and demand management capability and agility in the supply chain are

some of these capabilities, i.e., the ability of a supply chain to respond quickly to changes in supply and demand, as suggested by (Christopher & Peck, 2004).

Secondly, **ecological resilience** is not about measuring resilience, as it defines more how well the system can recover after an event since it might look normal from the outside (Walker et al., 2004), consequently rather than focusing on the speed that a system takes to bounce back after a disruption as it's the case for resilience engineering, instead ecological resilience measures the capacity of disruptions the system can withstand, so it's more about Adaptation capability (Adobor & McMullen, 2018, p. 1458). and of course, to achieve the adaptation goal, redundancy, flexibility, and self-organization are necessary to maintain ecological resilience.

When discussing redundancy and flexibility, (Christopher & Peck, 2004) was one of the first researchers who recommended these two elements in order to face disruptions and achieve supply chain resilience can be either by creating redundancy or increasing flexibility (Sheffi & Jr, 2005), functional redundancy that means having multiple parts that can do the same functions, so that if one part falls, the system will not break down, it enhances the resilience in the supply chain, because it opens up diverse options in the face of unexpected events (Adobor & McMullen, 2018) *for example* keeping an inventory, contracting with backup suppliers As for flexibility, it was confirmed by (Kamalahmadi et al., 2022, p. 1995) that " flexibility creates supply chain resilience by enhancing prompt adaptability during turbulence." Also, if redundancy comes with a high cost, flexibility can improve redundancy to make operations less expensive, for example, using flexible contracts instead of having particular parts (Adobor & McMullen, 2018).

Thirdly, **evolutionary resilience** is outlined as the ability to change, adapt, and transform, either with external or internal disruptions. It is a continuous process of innovating and improving one's state by exploring new opportunities in the field(Wang & Yamashita, 2015). Of course, it can be enhanced through social memory (shared memory of past experiences), system learning (gaining new knowledge and skills), and trust and collaboration, which are also fundamental components that contribute to the growth of evolutionary resilience.

To summarize, the authors believe that these three types of resilience (engineering, ecological, and evolutionary) must be present together in the supply chain to be resilient while maintaining synergy and interaction between them. This is because engineering resilience helps in being efficient and recovering quickly, ecological resilience focuses on adapting to changes, while evolutionary resilience insists on benefiting from opportunities when necessary.

Additionally, supply chain members need to acquire critical capabilities to achieve resilience-type goals. Capabilities and the three different types of resilience directly influence and impact the four phases of supply chain resilience in pre- and post-disruptions. These four phases serve as a general framework for achieving supply chain resilience. Hence, preparation. response, recovery, and adaptation can be considered as stages or phases of supply chain resilience, but also dimensions (Ponomarov & Holcomb, 2009; Zhuo et al., 2021).

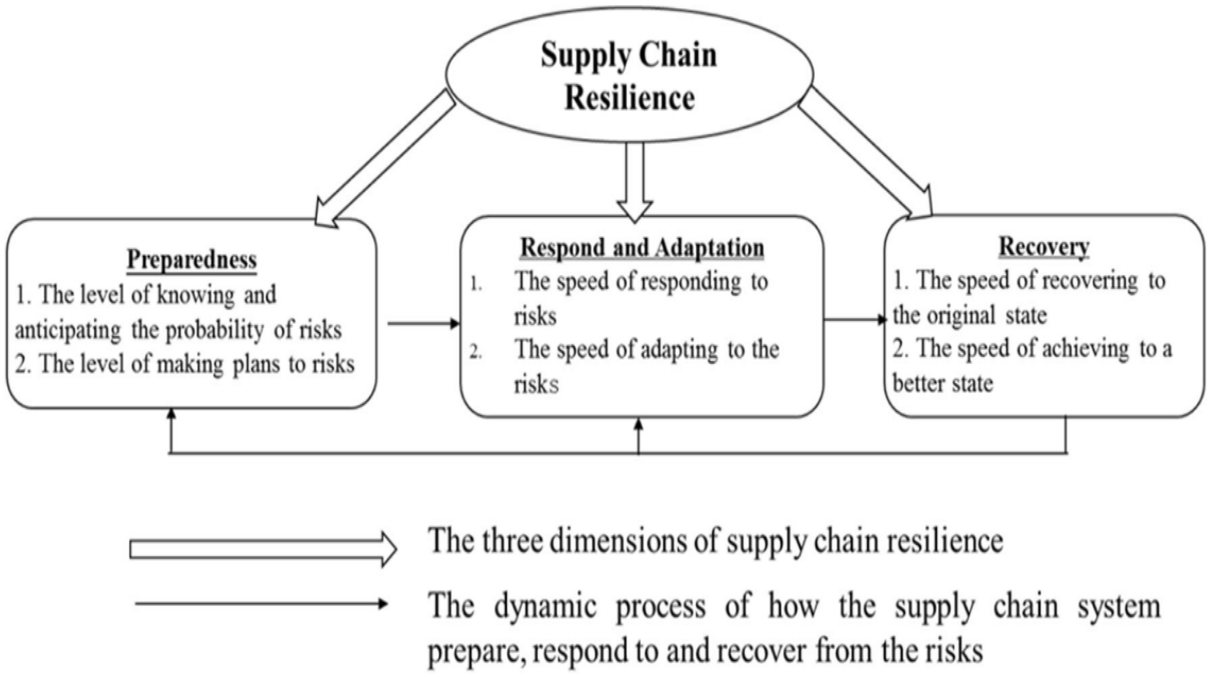
1.4 Supply Chain Resilience dimensions

As shown in Figure 7, achieving supply chain resilience involves four key elements and a structured framework. The process of achieving a resilient supply chain begins with the **preparation phase**, also known as the pre-disruption stage (Tukamuhabwa et al., 2015). Preparation involves anticipating potential risks and preparing for them, which helps managers or decision-makers predict the consequences of disruptions and prepare for them in advance, ultimately leading to a high level of supply chain resilience (Christopher & Peck, 2004; Kamalahmadi & Parast, 2016 ; Zhuo et al., 2021).

Additionally, in terms of **responding and adapting** to disruptions, it is important to note that the response phase should happen right after the disruption occurs. This is because a delay in reaction could lead to significant financial losses. On the other hand, taking immediate action can help a company gain a competitive edge, as noted by Field (Chowdhury & Quaddus, 2016),

Finally, from the perspective of **recovery**, the supply chain needs to have the ability to rapidly restore and bounce back to the original state because a supply chain with a high level of resilience will require less recovery time to return to the original or better state. (Munoz & Dunbar, 2015).

Figure 7: Three dimensions of supply chain resilience



Source: (Zhuo et al., 2021, p. 8313)

1.5 Strategies to enhance supply chain resilience

Understanding supply chain resilience requires a high-level framework, which can be provided by dimensions. Meanwhile, strategies represent practical approaches used to enhance resilience within each dimension.

In their study (Agrawal & Jain, 2021,p. 2515) developed a framework, as illustrated in Figure 8, that summarizes the theories of other authors. Within this framework, they identified 14 strategies to mitigate supply chain disruptions and achieve supply chain resilience, including preparedness, response, recovery, and adaptation, which were explained in detail as dimensions in the preceding section. Additionally, they outlined other strategies, as mentioned and explained in Table 1.

Table 1: Supply chain resilience strategies and definitions

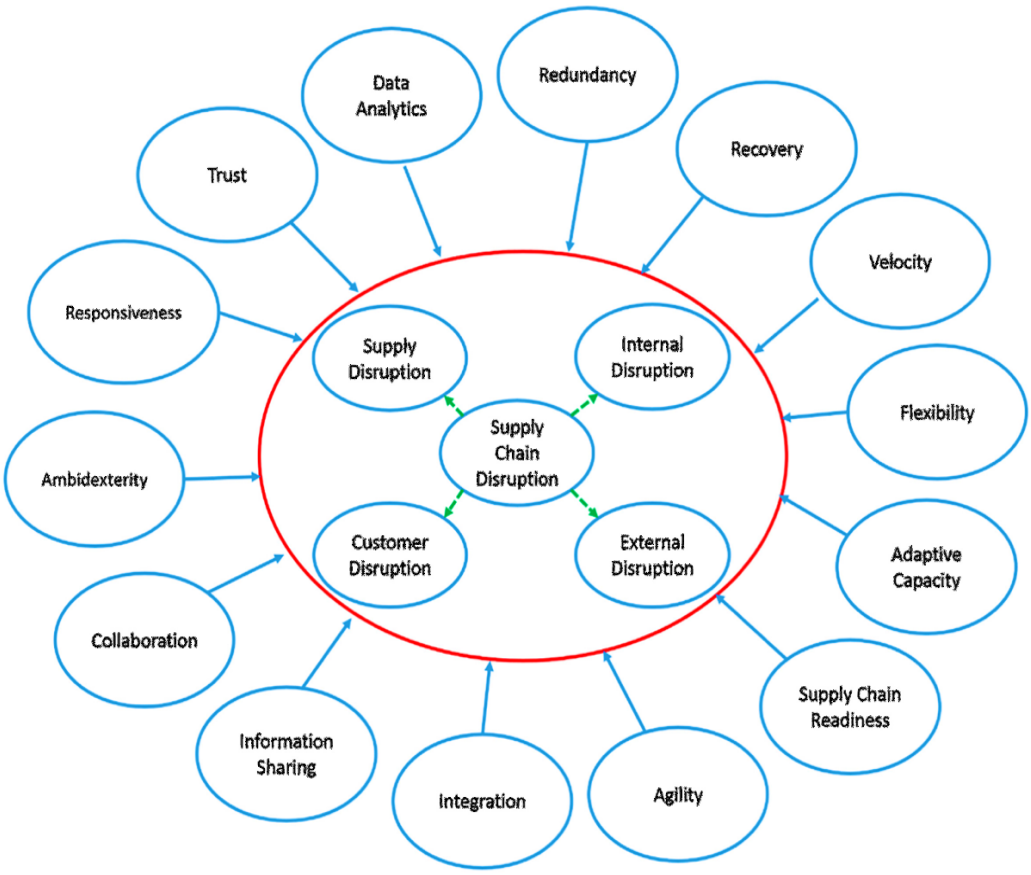
Supply chain resilience strategies	Definitions	Corresponding Authors
Redundancy reactive	The ability of a company of having a backup plan in case of a failure or supply shortages for example, it involves duplication of capacities, storage facilities, transportation, increasing inventories, reaching out multiple suppliers, in order to reduce risk and mitigate the disruptions, the redundancy and can be expensive, but can increase as well flexibility and considered as an effective solution.	(Agrawal & Jain, 2021; Sarkar et al., 2022; Sheffi & Jr, 2005; Tukamuhabwa et al., 2015; Yao & Fabbe-Costes, 2018)
Flexibility reactive	Is the firm's capacity to adjust with unexpected events and changing circumstances with less time and resources, it helps not only in mitigating disruptions but also in routine operations, by including flexible sourcing, sourcing and enables the organization to meet diverse needs and customer's expectation without excessive expenses	(Agrawal & Jain, 2021; Karl et al., 2018; Sheffi & Jr, 2005; Tang & Tomlin, 2008; Tukamuhabwa et al., 2015; Vargas & González, 2016)
Collaboration (Proactive & Reactive)	The ability of different entities involved in the supply chain to work closely together to achieve a common goal, it's an important factor to achieve supply chain resilience, and build a reliable network for the benefit of all parties by sharing information and resources, respecting deadlines, production and delivery schedules, it improves the	(Agrawal & Jain, 2021; Irfan et al., 2022; Jüttner & Maklan, 2011; Scholten & Schilder, 2015; Tukamuhabwa et al., 2015) 12/12/2023 09:19:00

	system's ability to manage future disruptions in all stages.	
Information sharing (Proactive & Reactive)	Exchanging information within participants of the supply chain, it's key strategy for supply chain resilience that enables to overcome the risk before and during disruption, it helps to share communication and rapid access to resources that are necessary for recovery like demand forecasts, order status and production schedule to reduce uncertainty, and avoid incomplete and inaccurate information	(Agrawal & Jain, 2021; Choi et al., 2001; Fayezi & Ghaderi, 2021; Soni et al., 2014)
Agility Reactive strategy	The ability of responding quickly to changes, while reducing the impact of disruptions, it involves having the visibility of overall supply chain, and a quick information sharing as well as velocity, agility is a reactive strategy that helps to identify potential failures like vulnerable suppliers, avoid overreactions and unnecessary actions.	(Agrawal & Jain, 2021; Christopher & Peck, 2004; Jüttner & Maklan, 2011; Karl et al., 2018; Tukamuhabwa et al., 2015)
Velocity reactive	Velocity refers to the speed of response of supply chain to changes and how fast it can adapt, it's a crucial factor for supply chain resilience because visibility and velocity determines how agile supply chain is. having a high velocity means that supply chain is able to bounce back quickly to its operations, find alternative sources and rapidly adapt.	(Adobor & McMullen, 2018; Agrawal & Jain, 2021; Christopher & Peck, 2004; Tukamuhabwa et al., 2015; Zhuo et al., 2021)
Integration	A proactive strategy that involves coordination of all activities in a company within external and internal partners, it	(Agrawal & Jain, 2021; Golan et al., 2020; Irfan et

Proactive strategy	improves the quality performance, it's a strategic decision to create interconnection between supply chain participants and ensure smooth and efficient flow of goods, information and resources within the supply chain to satisfy the end customer.	al., 2022; Sadeghi et al., 2021; Siagian et al., 2021)
Ambidexterity ***(Proactive & Reactive)***	A dynamic capability of having a balance exploiting the resources the company already have and exploring new opportunities, Ambidexterity helps to adapt with uncertainties and deal with negative impacts of disruptions and reduce risks leading to competitive advantage.	(Agrawal & Jain, 2021; Y. Wang et al., 2023)
Data analytics ***(Proactive & Reactive)***	Organizational capability that enables companies process, organize, visualize and analyze data to attain valuable insights, it's a combination of tools and techniques in order to anticipate challenges, prepare, respond to disruptions as well as mitigating risks and disruptions.	(Agrawal & Jain, 2021; Dubey et al., 2021; Munir et al., 2022)
Trust ***Proactive & Reactive***	Defined as reliance on partners within a supply chain, based on the expectation that others will act in good faith, trusting partners under conditions of uncertainties reduce conflicts and enhance cooperation as well as promotes adaptability and helps developing resilience.	(Karl et al ,, agrwal , song et al , Hussain et al)

Source: multiple sources

Figure 8: Supply chain resilience strategies to mitigate supply chain disruption



Source: (Agrawal & Jain, 2021,p. 2515)

to sum up, the framework developed by Agrawal and Jain in 2021, as shown in Figure 8, outlines various strategies that managers can use to build resilience within the supply chain and mitigate risks and disruptions. The strategy can be broadly classified into two categories proactive and reactive (Tukamuhabwa et al., 2015).

Proactive strategies aim to prevent disruptions before they occur, including appropriate supplier selection, knowledge management, inventory management, supplier development, portfolio diversification, increasing visibility, creating a risk management culture, collaboration, and ambidexterity.

The second category is **reactive strategies** that are implemented to respond when the disruption has already happened, such as redundancy, flexibility, ambidexterity, collaboration, efficiency, effective communication, trust and information sharing, and assuring supply chain agility.

Hence, many of these strategies can be considered **proactive and reactive** depending on the context of use, such as data analytics that is often applied proactively by analyzing the patterns and potential scenarios based on historical data to forecast demand and prepare for future operations and events. Hence, it can also be employed reactively when a sudden drop happens. For example, in sales, data analytics enables examining the root causes, enabling quick action and response to address this unanticipated situation.

Secondly, some strategies are interconnected and have some sort of reinforcement to each other (Tukamuhabwa et al., 2015) *for example,* velocity and visibility determine how agile the supply chain is (Christopher & Peck, 2004), also in the supply chain, trust, information sharing, effective communication are considered as enablers to effective collaboration. So, by recognizing and leveraging these interconnections, organizations can develop a more holistic and practical approach to supply chain resilience.

Finally, the strategies detailed in Table 2 have received significant attention in a variety of articles; nevertheless, multiple authors (Jüttner & Maklan, 2011; Kamalahmadi et al., 2022; Ponis & Koronis, 2012; Shekarian et al., 2020; Tukamuhabwa et al., 2015) outlined that some of these strategies carry more significance and stand out as particularly critical. These four strategies include increasing flexibility, encouraging collaboration, improving agility, and taking redundancy measures.

The question remains whether it is essential to prioritize only these four strategies within the supply chain to face disruptions and ensure resilience.

An attempt is made to address this question in the following part to have more insights into how supply chains work in the face of a crisis. But in summary, it can be stated from the previous figures and tables that strategies are classified into three categories and that there is interconnection between some practices. Some of these strategies can be approached differently depending on their importance. Consequently, a resilient supply chain necessitates the application of a combination of strategies since each strategy plays an essential and unique role, and the effectiveness depends on the nature of the disruption.

Table 2: Authors referencing critical strategies for supply chain resilience

Authors	flexibility	redundancy	Agility	Collaboration
Yang et al	1	1	1	1
Agrawal & Jain	1	1	1	1
Karl et al	1	1	1	1
Joshi &Luong	1	1	1	1
Tukamuhabwa et al	1	1	1	1
Song & al	1	1	1	1
Ergun et al	1			1
Tanuputri and Bai	1			1
Hussain et al	1		1	1
Roque & al	1		1	1
Holgado & Niess	1	1	1	
Gaudenzi et al	1		1	
Irfan et al	1		1	1
harrera et al	1			1
Shishodia et al	1		1	
Sá et al	1	1		1
Vargas & González	1		1	
Ponomarov & Holcomb	1	1	1	1
Gunasekaran et al .	1			1
Sadeghi et al	1	1	1	1
Sarkar et al	1	1	1	1
Agrwal et al	1			1
Scholten et al		1	1	1
Golan et al			1	
Total	**22**	**12**	**18**	**19**

Source: Multiple sources, Compelled by the author.

1.6 Theoretical framework for research methodology construction

This study explores how, in theory, organizations manage and enhance supply chain resilience in the face of unexpected events, and in previous sections, the research highlighted the dimensions of the resilient supply chain that provided a framework to understand supply chain resilience and underlined applicable strategies to mitigate risks and enhance resilience.

However, it was notable that there is a gap in understanding when to apply these strategies appropriately. In addition, most of the articles classify these strategies into two categories, proactive or/and reactive strategies that even the authors Field (Tukamuhabwa et al.,

2015p,5604) suggested that it would “be valuable for future research to develop a more elaborate categorization of supply chain resilience strategies.”

So, to fill in these gaps, align these strategies within each dimension, and address objective 2 of the research, a new conceptual framework was proposed, as mentioned in Figure 9.

the proposed model addresses all the strategies presented earlier in the literature review, along with their relative importance within the four dimensions and their alignment with the different stages/phases of supply chain resilience. The four phases are preparation, response, adaptation, and recovery, and they correspond to different periods:

- **pre-disruption** refers to the period before the unexpected event/or disruption occurs and outlines the day-to-day operations.
- **during disruption** refers to the period when the disruption is already happening and affecting the day-to-day operations.
- **post-disruption** refers to the period when the supply chain shifts from crisis management efforts to the process of recovering to restore normal operations.

Also, adaptation comes after response because it is strongly believed that once the disruption occurs and the supply chain participants respond by addressing urgent concerns to put the unstable situation under control, adaptation takes place to involve longer-term adjustments, enhance resilience, and prepare for probable future disruptions. ultimately, the aim is to recover completely in the end.

Additionally, the framework proposes a new category that was defined as **enduring strategies,** which means applicable strategies before, during, and after the disruptions. these strategies, for example (collaboration, efficiency, and data analytics …), allow companies to prepare, respond, adapt, and recover from unexpected events, providing sustained resilience that lasts for the long term.

Finally, the conceptual framework outlines the three other categories:

- **proactive strategies** focus more on giving participants in the supply chain the ability to prepare in advance. It is more regarded as a preventive measure that allows organizations to minimize the risks and mitigate the crisis.
- **reactive strategies**: more applicable when the disruption has already taken place in the supply chain, it encompasses the actions taken to respond and adapt quickly so that the effect will not be significant.
- **proactive and reactive strategies** contain all strategies used before and during the crisis to face unexpected events and mitigate risks.

Figure 9 : Proposed conceptual model for supply chain resilience

source: Author's creation.

➔ This chapter offers an analysis of the concept of the supply chain, covering its various stages and exploring the crucial role of organizational resilience. Organizational resilience that is divided into three categories: engineering resilience, systems resilience, and complex adaptive systems. The latter was given particular importance due to its relevance to supply chain resilience. The discussion highlights the challenges of defining supply chain resilience comprehensively and proposes a refined definition. The backbone of supply chain resilience is identified as comprising the preparation, response, adaptation, and recovery phases.

The study emphasizes the importance of adaptability, which has emerged as a key skill in various frameworks and by authors. The synergy among engineering, ecological, and evolutionary resilience lends a robust framework for efficiency, adaptability, and growth. This framework enables the chain to recover from disruptions, adapt to changes, and capitalize on new opportunities.

Furthermore, the chapter stresses on the importance of capabilities and strategies in enhancing supply chain resilience. Several authors identified critical strategies such as improving flexibility, fostering collaboration, enhancing agility, and implementing redundancy measures. This chapter proposes a model that incorporates these strategies across different phases while introducing the concept of enduring strategies.

In conclusion, the study provides a comprehensive understanding of the complex interplay between organizational and supply chain resilience and the significance of strategies to enhance it. This understanding lays a solid foundation for a cohesive framework for navigating disruptions and cultivating resilient supply chains within a dynamic business landscape. The proposed model aims to resume the literature's propositions and to be validated through qualitative research in industry settings by bridging theoretical propositions with real-world applications.

2 METHODOLOGY OF RESEARCH

Methodology is "the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge" (Patel & Patel, 2019, p. 48); the same authors confirmed that the research, in general, aims to uncover answers for inquiries using the application of scientific methods to reveal hidden truth that remains undiscovered.

this section encompasses first the theoretical framework, which enables the building of the conceptual background of the research methodology, and then a detailed methodology of the research approach chosen, which is prior empirical data; it serves as a guideline and consists of the research design, population of the study, sampling techniques, research instrument, methods of data collection and criteria for informant's selection and explanations of methods of data analysis

2.1 Research design

Research design is "the plan that guides a researcher in the process of collecting, analyzing and interpreting data and information for clarifying and solving organizational/national problems" (Osuagwu, 2020,p 44), and it can be divided into different categories since each type of research has a distinct purpose for exploring the phenomena (Runeson & Höst, 2009).

For example, descriptive research aims to precisely illustrate the characteristics of a specific individual, situation, or event using surveys, observations, content analysis, and interviews. often used when it's necessary to obtain a bigger picture of the subject.

Also, **diagnostic research** focuses on determining the frequency of occurrence or the interconnection of two different elements.

On the other hand, **exploratory research** aims to become familiar with a phenomenon and to gain new and fresh perspectives on it. So, the main goal is to explore and achieve an in-depth understanding as well as generate ideas and hypotheses for further research.

Therefore, to select the research design, it is essential to consider the nature of the research question or the issue that is being addressed, as well as the researcher's personal experiences and the audiences for the study (*Creswell.J.w.d*, 2014.)**.**

Accordingly, **the exploratory method was chosen** to be more familiar with supply chain strategies for enhancing resilience inside companies and gain new insights and ideas about this subject. This decision was made because integrating exploratory research into a study can enhance quality and add insightful information to a study, providing researchers the latitude to

employ innovative approaches for achieving the most comprehensive understanding of a subject[2].

Also, "exploratory research is characterized by its flexibility. When a problem is broad and not specifically defined, the researchers use exploratory research as a beginning step" (Swaraj, 2019, p. 666). Consequently, this study design can be considered a valuable means of understanding what is happening, asking questions, and examining phenomena with a fresh perspective.

2.2 Research questions and objectives

To support the objectives and aim of this paper's research and to validate the proposed conceptual framework, empirical research questions have been developed to address the identified gaps. These questions are designed to guide the investigation and provide a framework for the research, and provide a systematic and meticulous framework.

- Q1: How do companies currently conceptualize and understand supply chain resilience?
- Q2: What are the practices and strategies employed by resilient supply chains before, during, and after crisis situations in companies?
- Q3: What are the most critical strategies employed by companies, and can they be generalized across different industries?

Goals/objectives

Goal /objective 1: Explore how the supply chain experts currently conceptualize and understand supply chain resilience and the critical components identified in their understanding

- Conduct interviews with experts in the selected companies.
- Analyze data to identify matching patterns and common themes and compare them with the theoretical framework.
- contribute to the knowledge by providing a clearer understanding of how companies understand supply chain resilience.

[2] https://en.wikipedia.org/wiki/Exploratory_research

Goal /objective 2: Identify practices and strategies for resilient supply chains before during and after crises.

- Conduct qualitative interviews with experts in companies that have demonstrated good levels of resilience during crises.
- Identify and document the best practices and strategies employed by these resilient supply chains.
- Analyze and synthesize the findings to provide recommendations and guidelines for other companies in enhancing their supply chain resilience

Goal /objective 3: outline the level of importance of strategies to enhance Supply Chain Resilience.

- Conduct qualitative interviews and data collection process to gather information from experts
- Analyze the collected data to determine the current effectiveness of strategies in supply chain resilience among different industries.
- Compare the findings with the existing conceptual framework to provide insights into the industry's overall resilience performance.

Overall, the goals and objectives of the research are to contribute to the understanding of supply chain resilience by **uncovering best practices** and strategies for managing **resilience before, during, and after crises. Identify the level of effectiveness** and compare it with the literature as well as **validate the proposed conceptual model** across different industries.

2.3 Research strategy and instruments.

The methods are the techniques, instruments, and tools used to acquire the knowledge, such as interviews, surveys, and questionnaires. These methods include techniques for analyzing data, like statistical methods. Additionally, researchers use methods to conduct the research process, such as how to conduct sampling.

There are three types of research strategies: quantitative, qualitative, and mixed methods (combining quantitative and qualitative methods). These strategies involve designing studies, collecting data, analyzing collected data, examining relationships or discrepancies between variables, and interpreting research findings to communicate results (Gentles et al., 2016; Osuagwu, 2020).

Quantitative research: This form of research primarily focuses on quantifying and measuring phenomena. For example, surveys are used to gather population economic statistics for further analysis. it relies heavily on methods like questionnaires and surveys considered as primary data, i.e., data that has not been previously published or analyzed (Patel & Patel, 2019)

Qualitative research: This type of research goes beyond numbers because it focuses more on understanding human behavior, opinions, emotions, and attitudes by observing (Patel & Patel, 2019) and using methods like interviews, focus groups, content analysis, case studies, etc.…

Mixed methods: This research combines both quantitative and qualitative data.

For this research, and since it has been decided that the research strategy will be exploratory, the research will employ **a qualitative method by using semi-structured interviews** to interview supply chain experts about their understanding of supply chain resilience and their practices to enhance it. Because in contrast to the other methods of verifying or disproving a phenomenon, qualitative research focuses on understanding, interpreting, and explaining a complex phenomenon (Nha, 2021). Additionally, the collection procedures in qualitative research involve four types: interviews, observations, documents, and audio-visual materials (*Creswell.J.w.d*, 2014.)**.**

Interviewing is the most commonly used form of data collection in the qualitative research, and qualitative interviews often focus on the "why" and/or "how" reasoning behind a respondent's answer, granting respondents the freedom to openly share their thoughts and experiences that may lead to the discovery of fresh avenues for further investigation.

Consequently, qualitative research was the appropriate method.

As for the **research instruments,** this research is based on a primary type of research. The primary research methodology involves conducting interviews and analyzing the primary informants' opinions and insights. This thesis will employ semi-structured interviews as an instrument for qualitative research.

The author (Al.habsyi, 2022) stated that a semi-structured interview is described as an exploratory interview guided by a general topic, the opposite of structured interviews that have more formalized and fixed questions, so this instrument has more flexibility and ability to address complex issues allowing new questions based on the interviewee's responses.

Also, the same authors confirmed that to have a successful interview, it is important to have a balance between primary questions, follow-up inquiries, and probes, and it is crucial for the interviewer to prepare and have an interview guide prepared thoroughly. That means "a type of informal grouping of topics and questions that an interviewer would ask in different ways to different participants" (Alhabsyi, 2022, p. 24)

According to (Kallio et al., 2016), the interview guide involves a series of questions that guide the conversation towards the research topic.
the author's (Kallio et al., 2016) stated that to confirm the relevance of the interview guide, pilot testing needs to be done, which means testing the interview with potential respondents to check if some questions need to be deleted and maybe other questions can be added.
Therefore, relevant questions were developed for this study to cover the three objectives and research questions and fill in the gaps, as illustrated in **the interview guide** Annexe **2.**
The purpose of conducting this semi-structured interview is to understand how various companies perceive supply chain resilience. And learn about their best practices and strategies for coping with supply chain disruptions., as well as check the level of effectiveness of enduring strategies and how much can be generalized.

2.4 Sample size and sampling techniques

The authors (Vasileiou et al., 2018) outlined that multiple qualitative research experts avoid asking how many interviews are enough. There is indeed variability in what is suggested as a minimum. Still, the primary consideration in qualitative research interviews is to contemplate the saturation factor, often described as the point in the data collection process where no new or pertinent information is gained it can be described as well by the state when collecting additional data has no longer leads to new theoretical insights or uncovers additional attributes of the core theoretical categories.
Not only the saturation factor is important, but several elements are considered important for the quality of qualitative research, such as the extent of the study, the characteristics of the subject matter, the volume of valuable insights gathered from each participant, the inclusion of obscured data, and the chosen qualitative methodology and study structure (Morse, 2000).
Considering that the choice of the number of samples depends on the nature of the topic, the resources available, and the amount of useful information gathered, it was necessary to select a representative sample. consequently, ten participants were chosen from different industries in Lithuania, Saudi Arabia, and Morocco, specifically in Northern Europe, North Africa, and the Middle East. This selection addressed the global perspective and compared the results across diverse populations while respecting cultural variation and avoiding ethnocentrism. so this choice of sampling and location of the study was deemed appropriate because of the exploratory nature of this research and the focus on identifying underlying ideas about the topic, as well as considering the resources, timing, and accessibility constraints.

On the other hand, the sampling selected is a non-probability sampling with a purposive technique**.** also known as the purposive technique, aims to select so the wider population does not have the chance to participate, (*Creswell.J.w.d*, 2014.)**.** This type of sampling as opposed to probability sampling employed in quantitative research that is based on a random selection of the population, and each individual in the population has an equal probability of being selected

Since not all the population has an equal chance of being selected, purposive sampling can also be used to select participants who meet specific or narrow criteria. The selection for this study was for managers, seniors, and supervisors in the supply chain. this choice was made because the key informants are being selected for their expertise and knowledge of the subject matter. It's suitable for the research objectives, and the population selected possesses more knowledge and expertise related to supply chain resilience, so it will help to regroup rich and valuable insights, especially since they might have access to critical information that is not available for every other employee.

2.5 Criteria for informant's selection

It is important to explain the specific criteria used to select the informants, and for this qualitative research, four main criteria were chosen:

- **Expertise and knowledge:** It is believed that experts who have significant experience have more valuable insights and are more related to strategic practices and decisions applied before, during, and after disruptions, so it's more relevant to the research objectives, and the interviews will be conducted with respecting the confidentiality and anonymity of the informants.
- **Accessibility:** The focus is more on informants willing to participate in interviews and available for further discussion, considering their schedules and time differences**.**
- **Trustworthiness and Credibility**: involves the reliability and honesty of informants to share insights and their experiences, especially by providing accurate and trustworthy information.
- **Decision-Making Authority:** By focusing on informants who can make decisions in the face of disruptions, these individuals occupy crucial roles in forming policies and strategies to take action.

2.6 Data analysis methods

For this study, **content analysis** was the primary analytical approach. This involved transcribing interviews and examining them through multiple iterations. **Color coding** techniques were also used. Both **deductive and inductive** analyses were utilized. The deductive method initially applied predefined categories drawn from existing theories or frameworks to structure the data. This helped to evaluate the reliability and validity of the theoretical framework used to categorize the data and investigate the relationships to form new insights through inductive analysis (Delve, Ho, L & Limpaecher, A 2023). This facilitated the organization of information based on established concepts. An inductive approach was also adopted, allowing for the emergence of new categories and subcategories directly from the data itself. This combined method facilitated a rigorous analysis capturing both predetermined and emergent elements within the dataset, enhancing the depth and breadth of the research outcomes.

and data interpretation follows **qualitative observation,** providing an understanding rather than numerical data and it will be required to review the findings to approve and give further comments if needed

➔ This chapter examined the methodology used to explore the concept of supply chain resilience by using qualitative research methodology to address three key research questions.

The first research question aimed to understand how companies perceive and comprehend supply chain resilience. The objective was to highlight the diverse conceptualizations across industries.

The second research question explored the practices and strategies implemented by resilient supply chains before, during, and after crises. This investigation aimed to gather insights into operational strategies across various stages of disruption.

The third research question aimed to identify critical strategies employed by companies, probing the potential for generalization across diverse industries. The objective here was to outline the level of importance of certain strategies and compare them with the literature.

To facilitate a comprehensive exploration, the research employed semi-structured interviews with ten carefully selected participants from Northern Europe, North Africa, and the Middle East. The purposive sampling technique ensured representation across industries, enabling the collection of rich, diverse insights from managers, seniors, and supervisors directly related to supply chain operations.

The selection criteria encompassing expertise, credibility, decision-making authority, and trustworthiness were fundamental benchmarks in participant selection. These criteria ensured the inclusion of individuals with profound knowledge and experience in the domain, enhancing the richness and relevance of the collected data.

The analytical process centered on content analysis, employing both deductive and inductive approaches. Transcriptions of interviews helped with the examination and analysis using color-coding techniques. This methodological approach aimed to extract, categorize, and derive patterns from the collected data.

In summary, this research journey employed a well-defined exploratory methodology, drawing insights from diverse industry representatives through qualitative interviews and rigorous content analysis. The findings aim to highlight the multifaceted landscape of supply chain resilience, offering nuanced perspectives and practical strategies for businesses navigating disruptions.

3 ANALYTICAL PART. EMPIRICAL DATA ANALYSIS AND FINDINGS.

3.1 Data analysis

After developing an interview guide that outlined the key questions, the interviews were conducted either online via Microsoft Teams or via messenger but also face to face; each interview lasted about 20-45min depending on the flow of information; additionally, the interviews were conducted mainly in English for the Lithuanian interviewees, in French for the Moroccans, and Arabic for the Saudi Arabia interviews to make sure that the communication is conducted effectively, also with the participants consent each interview was recorded, the boarder subject was explained in the beginning to encourage participants to share their perspectives and elicit detailed responses.

Once the semi-structured interviews were conducted, the recordings were verified and transcribed automatically by an online website, but a comparison between what was generated automatically and the recorded interviews was still necessary in order to make sure that there was no missing information or differences.

Data analysis began with reviewing the transcripts to delve deeper into the collected data. However, it was necessary to repeatedly check and confirm the transcripts with each participant to ensure an accurate and practical understanding before content analysis, could begin.

The aim of using content analysis in this research was to organize, analyze, and interpret the data by blending deductive and inductive analysis, as explained in the methodology section. Color coding was used to make the data easier to understand.

The research employed deductive analysis to categorize the data based on existing theories and literature. Additionally, inductive analysis was used to identify new concepts. By combining both analyses, the research ensured a comprehensive approach to the investigation. Consequently, data categorization proved to be a practical step in uncovering patterns or themes within the dataset.

As presented in Table 3, the categories combine deductive and inductive reasoning. For instance, the second category - experts' comprehension of supply chain resilience - as well as the third, fourth, and fifth categories, namely "proactive," "reactive," and "enduring," seem to correspond with pre-existing theories or frameworks in supply chain resilience. As well as for some subcategories such as adaptability, responsiveness, risk management, collaboration, and knowledge management….

On the other hand, inductive categories are related to **experts' experiences with disruptions** (human-related, logistic, regulatory, technical, and technological disruptions) and **experts' choices for critical strategies.** Additionally, these experts have identified new subcategories related to adaptability, responsiveness, risk management, collaboration, and knowledge management. These subcategories were not part of any predefined framework but surfaced during the analysis of interviews and emerged from the data itself, providing new insights into effective disruption management.

Table 3: Data categorization for qualitative analysis

Category	Subcategory
1. **Experts 's experiences with disruptions**	a) Human related disruptions b) Logistic and supply disruptions c) Regulatory disruptions d) Technical disruptions e) Technological disruptions
2. **Experts' understanding about supply chain resilience"**	a) Adaptability b) responsiveness c) agility d) preparation e) adaptive learning f) risk management
3. Proactive strategies "Preparing phase"	a) planning and analysis b) collaboration and knowledge management c) risk mitigation
4. Reactive strategies "Responding phase"	a) collaboration and communication b) risk management c) operational agility
5. Enduring strategies "Preparing, responding adapting & recovering phase"	a) knowledge management b) data analysis c) collaboration d) communication and information sharing

5. **Expert's** **critical strategies**	a) collaboration b) integration c) knowledge management d) data analytics e) flexibility

Source: author's creation

3.2 Credibility and dependability

The authors (Whittemore et al., 2001) defined credibility as the conscious effort to establish confidence in the accurate interpretation of data. This study was conducted with credibility in mind, using techniques such as allowing participants to review the transcripts to confirm accuracy and maintaining detailed documentation throughout the research process.
Furthermore, this study maintained consistency in data collection by using standardized protocols during the interviews. This ensured that all participants were asked the same set of questions, and any necessary clarifications were consistently given to the interviewees, all to ensure the dependability of the study.

3.3 Ethical consideration

- Confidentiality and Anonymity: The identities of the participants were not revealed, and any sensitive information shared during the interviews was eliminated. Additionally, the identities were anonymized using the pseudonym REP, and the interviewees were reassured and informed.
- Data Handling: The data was handled with responsibility, ensuring its security and protection.

3.4 Findings and results

3.4.1 Background information

The qualitative research was conducted with ten interviewees from different industries in different countries, and all the interviewees varied in their roles and responsibilities within their

respective organizations, ranging from supply chain performance manager to transport coordinator supervisor; their experience in their roles ranged from 3 to 12 years.

Since the supply chain includes various facets and related roles, the interview targeted the director of drilling and blasting (extracting raw materials) with 12 years of experience, managers of inventories, import procurement, purchasing, and supply chain management with 3 to 5 years of experience and supervisors of customer service, operational planners, sales, transport coordinators, and costs and inventory with 3 to 6 years of experience as shown in Table 3.

Table 4: Overview of the interview participants

Participant ID	Years of experience in position	Position and role	Company Industry	Department	Country
REP1	4 years	Inventory manager	Food industry	logistics	Morocco
REP2	3 years	Import procurement manager	Industrial industry	Import-procurement	Morocco
REP3	4 years	Purchasing manager	Food industry	Purchasing	Morocco
REP4	3 years	Customer service supervisor	Agriculture (Chemical solutions)	Customer service	Lithuania
REP5	3 years	operational planner senior	Agriculture (Chemical solutions)	Planification	Lithuania
REP6	4 years	Sales supervisor	Transport company	Transportation	Lithuania
REP7	4 years	transport coordinators supervisor	Agriculture (Chemical solutions)	Transportation	Lithuania
REP8	2 years	Supply chain	Construction company	Supply chain	Saudi Arabia

		management governance & performance Manager			
REP9	12 years	Drilling and blasting director	Construction company	Drilling and blasting (extraction raw material)	Saudi Arabia
REP10	3 years	Costs and inventory supervisor	Construction company	Inbound logistics	Saudi arabia

Source: Author's creation

Responses from the informants with these different roles and experiences offered diverse viewpoints while taking into consideration how their roles might influence their perspectives on supply chain resilience strategies, but it also allowed a very structured examination and comparison of their different insights.

3.4.2 Expert's experiences with disruption

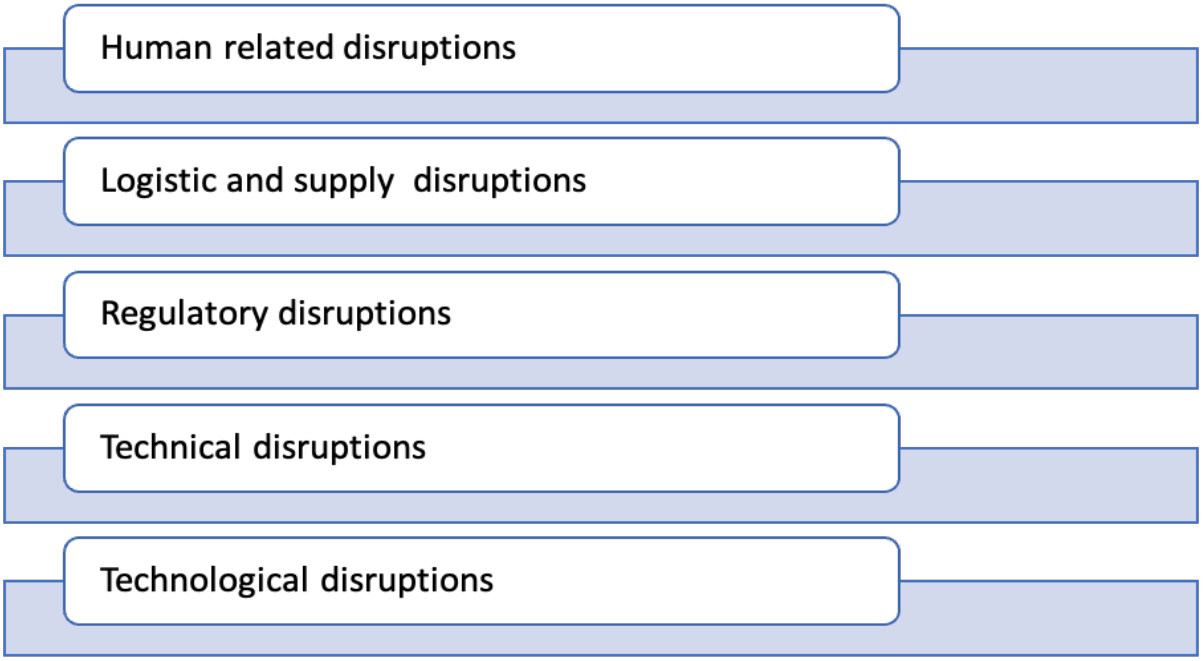
To align with objective number 1 of the qualitative research that is to explore how currently supply chain experts conceptualize and understand supply chain resilience and the key components identified in their understanding. two main questions were asked:

- Q1: Based on your experience, what types of disruptions (unexpected events) have you encountered in the supply chain operations?
- Q2: How would you describe or define supply chain resilience?

The first question aims to prepare the context for the interviewee to discuss supply chain resilience after knowing that the unexpected events they faced help in comprehending the need for resilience, or at least it follows a logical sequence as resilience strategies in the supply chain are often developed based on the type of disruptions that occurred.

Therefore, after collecting the responses from the experts regarding the disruptions in their supply chain operations, it was noted that different types of disruptions might appear in the supply chain, which was sub-categorized into five types, as mentioned in Figure 10.

Figure 10: Experts identified supply chain disruptions



Source: Author's creation

Firstly, human-related disruptions that stem from employees' actions or capabilities may interrupt the flow of the entire chain. For example, **REP06** highlights driver-related interruptions due to the driver's irresponsibility to show up in the scheduled time slot for inconvenient reasons. Such disruptions cause daily issues to the entire flow, leading to delays for customers and the accumulation of products at the loading site.

Additionally, human-related disruptions can result from human errors, as mentioned by **REP01 and REP07**. For example, **REP01** described that the major interruption they have is generated by the errors the employees make while entering the data in the system, leading to discrepancies between the correct physical inventory and recorded inventory levels. Describing it as:

QUOTE 2: *Most of the time, it's* ***human errors in inventory handling*** *because sometimes, when putting the data entry or recording transactions into the system we are working with, the team might* ***enter typos or incorrect input of quantities*** *that lead to discrepancies between the correct physical inventory and recorded inventory levels, misplacement of items sometimes I mean the items might be mistakenly placed in the wrong storage location within the warehouse which causes difficulties in locating items, and sometimes* ***wrong orders are being packed and shipped even*** *resulting huge losses and all the time the reason is the confusion in an item identification that leads the team to pick the wrong item from the inventory shelves. and pack it.*

Secondly, logistic and supply disruptions that involve challenges related to issues with warehousing and distribution. Supplier shortages, issues with quality, inventory shortages, and customs clearance, and these types of disruptions generally interrupt the smooth movement, handling, or delivery of goods from one point to another within the supply chain network.
Actually, out of **ten interviewees**, **six informants** have mentioned this type of disruption; for example, **REP09** has described their major disruption as:

QUOTE 2: *The fact that projects in Saudi Arabia are really developing, and especially that our company is one of the biggest contractors with the government, we're having such mega projects, where there's a sudden need for large quantities of materials, parts, and consumables but still we have a* ***shortage of suppliers****. in fact, when we get the project and place our orders, we are limited by the mobilization time, which is the period required to prepare, assemble, and deploy resources, but often, it's considered* ***a short time compared to the supplier's ability****. Especially since we need large quantities of materials, let's say 68 drilling machines. And our two local suppliers told us that they can deliver this in three years. And our total contract duration is one year.*

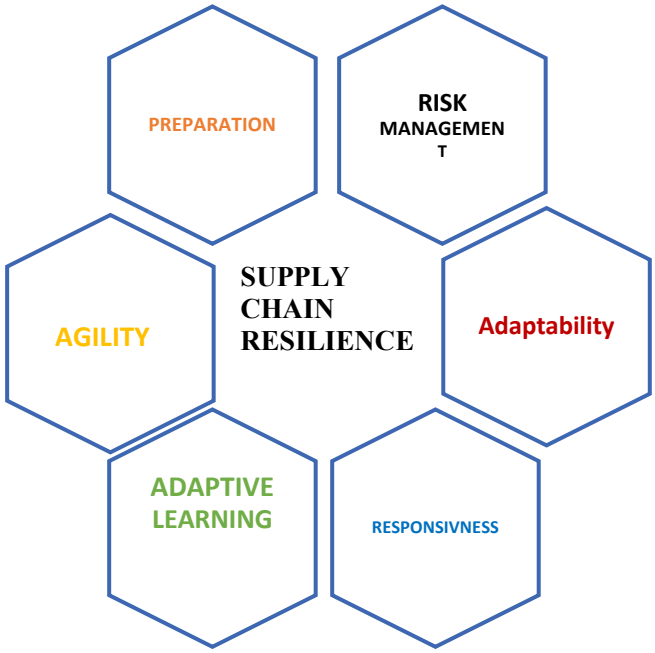
Thirdly, regulatory disruptions, especially for the three interviewees **REP02 /REP03** from Morocco, since their food industry imports most of the raw materials and production compositions from international companies, including China and Europe, so most of the time, the tariffs change as well as the documentation process and even the inspection procedure that might affect the sourcing strategies, the costs and delivery schedules.
Fourthly. Technical disruptions According to the **REP04 / REP05 / REP07,** interruption of supply chain operations is involved as well due to technical issues on site for multiple reasons, from a breakdown in the production mechanisms to an issue within machinery equipment.
Finally, technological disruptions that were mentioned once by the interviewee **REP08** confirmed that they had been targeted by a complex cyber-attack two times a year and commented that:

Quote 3 *The cyber-attack impacted all the supply chain operations inside the company, which really showed how much* ***our cybersecurity is not as vulnerable*** *as it seems, they took control and access over all archived data like history data, customers data, inventory levels data. Also, they closed all the systems, and we could no longer make a transaction in the system or work on it until a sum of money was paid. Actually, I mentioned this disruption because it had a huge impact on our daily supply chain operations. until it was solved.*

3.4.3 Expert's supply chain resilience framework

The interviewees of this study have provided a wide range of definitions of supply chain resilience, but despite this diversity, a common pattern appeared through the occurrence of the meaning of six keywords in their interpretations, as illustrated in Figure 11: Preparation, Adaptability, agility, responsiveness, Adaptive learning, risk management.

Figure 11: Supply chain resilience expert's framework.



Source: Authors creation

Among the participants, four interviewees defined supply chain resilience as the ability to respond and adapt to changes, while another interviewee called it "collaborative functions and teamwork." Another described it as "the action of being two steps ahead and anticipating."
Also, two interviewees linked supply chain resilience to risk management. For example, **REP02** was defined as:

Quote 3: *Supply chain resilience is the* ***ability to anticipate*** *these challenges and being able* ***to manage the risk*** *for example if the company can anticipate that these delays in customs clearance might happen or at least* ***prepare two plans instead of one*** *there will be less surprises inside the supply chain.*

Additionally**, two interviewees** commented that resilience in the supply chain comes with learning lessons either after the disruption ends or from what already happened in the past to improve, so it is considered adaptive learning.

And finally, participants expressed resilience as proactive readiness, suggesting that quick decision-making and adapting quickly are pivotal elements.

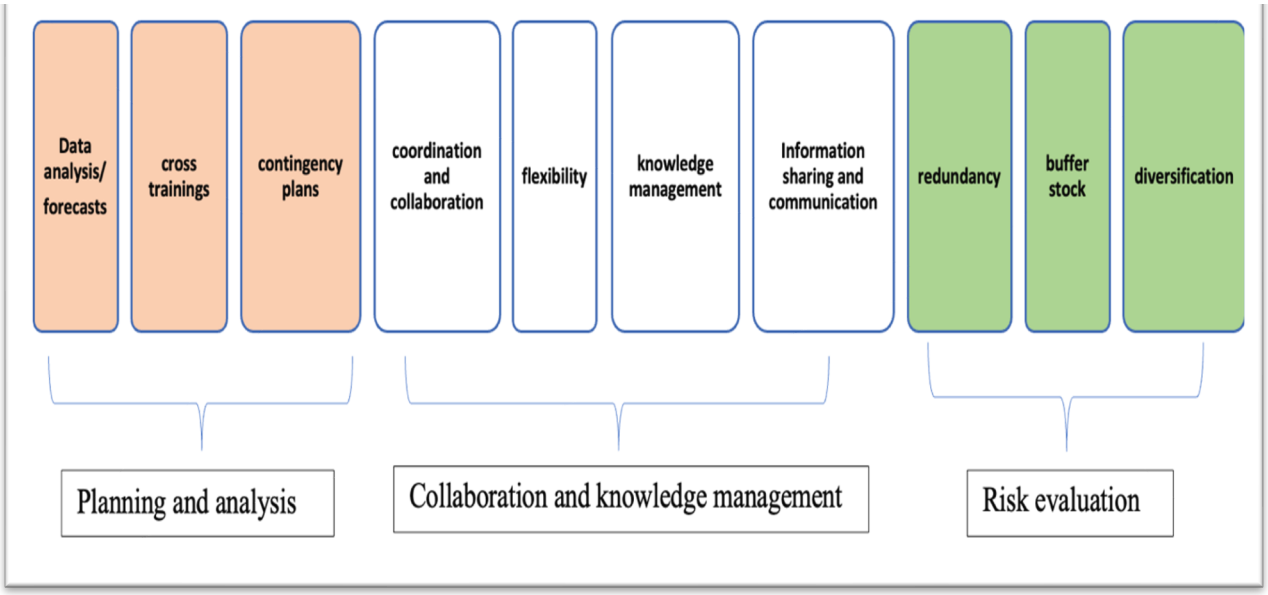
3.4.4 Proactive strategies: practices employed in the Preparing phase

For the purpose of alignment with objective num two i.e., to identify practices and strategies for resilient supply chains before, during, and after crisis situations, the first question aimed to search about the strategies and practices employed by supply chain contributors before the disruptions occur meaning in the preparation phase:

- Q5: Could you provide specific examples of practices or strategies that have proven to be effective **in preparing** for disruptions in your organization?

During all the interviews, multiple terms were mentioned by the participants. They discussed various practices that could be employed to prepare for unexpected events, depending on their respective roles and responsibilities. These practices were further sub-categorized, as explained earlier.

Figure 12 : categories and subcategories for proactive strategies



Source : Author's creation

For example, only **four participants** emphasized the significance of planning and analysis using data analysis. They all shared the same idea about how important it is to provide insights and help forecast demand, prepare different scenarios, and identify potential risks. For instance, the participant identified as **REP03** commented that:

QUOTE 4: "Some practices are implemented in order to prepare the supply chain for maintaining operational continuity that involves facing disruptions; I mean, for example, if we **analyze the data** and the reviews done by the procurement department, we can easily define the supplier performance .and identify the risk, and verify if the contracts can still be extended or changed in case of bad performance that might put the procurement into more risks."

Also, **two participants** agreed that ***contingency plans*** help pre-determine the steps to be taken to prepare for any disruptions to minimize the negative impact of these disruptions. As well as doing some cross-trainings to avoid human errors which **REP07, REP08, and REP01** confirmed**.**

Additionally, the terms **coordination, collaboration, Information sharing, communication knowledge management, and flexibility** were mentioned at least one time by all participants. Especially by the experts who manage a group of employees or include different partners (suppliers, carriers…).

As for the last category, risk mitigation, strategies like diversification and buffer stock were mentioned only by departments related to purchasing procurement, inventory, import, and supply chain and performance managers as valuable practices to ensure continuity and manage fluctuations.

⇨ Finally, while proactive strategies are important to prepare for the disruptions, two participants, **REP06 and REP09,** mentioned that some disruptions can be unpredictable, so "preparing is not always a possibility or doable.**"** as commented by the director of drilling and blasting who provided an example of a supplier shortage for a particular exclusive material only supplied by a monopolistic supplier. In such cases, it is impossible to prepare for any interruption caused by the supplier; instead, dealing with it once it happens is the solution, even if the contracts are flexible.

3.4.5 Reactive strategies: practices employed in the responding phase

Regarding the strategies and practices employed by supply chain contributors once the disruptions occur, i.e., in the responding phase, a second question was asked to participants:

- Q6: Similarly, could you provide examples of strategies that were successful **in responding** to disruptions during their occurrence?

The same method of coding was used, and multiple terms were identified via all the interviewees and sub-categorized into three types as mentioned below:

1. Collaboration & communication	2. Risk management	3. Operational agility
Collaboration	**Data analysis**	**Agility**
Communication	**Transparency and visibility**	**Flexibility & efficiency**
Information sharing	**Redundancy**	
Cross trainings		

All the interviewees, without exception, mentioned at least one strategy from the first subcategory because all the participants, with their different roles, agreed that the information must be shared with all the stakeholders once something happens. also, collaboration between the employees in the same department, or even between different departments or other stakeholders, is necessary and sometimes even obligatory, as **REP07, REP05**, and **REP04** confirmed.

On the other hand, ***data analysis*** was mentioned by five interviewees who agreed that data analysis is the best tool to search for the root cause and identify alternative solutions and the most effective response strategies. this could involve rerouting shipments in case of difficulties in unloading trucks, reallocating inventory, and finding alternative carriers or suppliers.

Only one interviewee, **REP08,** mentioned that ***transparency*** with the clients and verifying the ***backup systems*** is necessary whenever a cyberattack happens.

Also, three interviewees agreed that agility is needed as a practice to respond and change quickly whenever it's needed. for example, the **REP04** commented that:

QUOTE05: It's important always to have a ***visible goal***. For instance, if the ship-to refuses to unload the truck, it must urgently be rerouted to another customer. So, when it happens, the reaction of finding a new client with a new address, which is considered as ***plan b***, needs to be done ***very quickly*** because extra costs are charged. The driver is sometimes considered to be in a dangerous situation with the goods since they are explosive materials. So, ***the collaboration*** between the transportation coordinators and client service is obligatory so that the information received from the contractor will reach the right person at the right time.

3.4.6 Enduring strategies: practices employed in the preparation, responding, adaptation, and recovery phase:

In order to align with objective number 2 of the qualitative research, i.e., to identify practices and strategies for resilient supply chains before, during, and after crises, another two questions have been asked of the participants:

- Q7: Could you highlight specific strategies that were implemented **to adapt** your operations to the requirements of the changed environment?

- Q8: Similarly, could you provide practices or strategies that were successful **in recovering** from disruptions?

These two questions aim to verify the commonality of strategies used in each phase of the supply chain resilience. The results were quite diverse, demonstrating both alignment and divergence across various viewpoints; for example, when talking about the adapting phase, the interviewee **REP06** mentioned ***that adaptation is not always a possibility*** because once a disruption happens. Actions take place, and immediately, the operations restore to the initial phase, so in their sector, it was stated that adaptation is not an option; instead, having a robust system in the first place is more convenient. On the other hand, the other experts, **REP02, REP09, and REP03**, monitor the situation after responding and adjusting the contracts, resources, and processes to the new environment; others rely on the flexibility of the team, collaboration of the stakeholders, and coordination between the departments to align with the new standards.

Also, **three participants** mentioned the data analysis as a key for adapting, such as **REP1,** who commented:

Quote 6: “When it is hard to locate specific inventory items due to items being misplaced in the wrong storage locations, I found **after analyzing** the info that the misplacement was primarily due to unclear labeling, so I asked **the help of a team member** to reevaluate the labeling system, then we implemented a new labeling system. and **open communication channels** were established for addressing any emerging issues promptly”.

Regarding the recovery phase, **seven participants** predominantly emphasized the importance of data analysis. They highlighted its role in assessing and reassessing the situation post-disruption, and **REP06** particularly underscored the significance of visiting clients and rebuilding trust as a critical factor in restoring relationships. Moreover, all participants involved directly with clients, suppliers, and carriers agreed on the critical role of communication and collaboration with these stakeholders. Those involved directly with the employees insisted on the reactivity of their team members and focused on how knowledge management helps, for example, the inventory manager cited, “Since most of the disruptions are coming from human error in this department, I would rather say the key is to have a team that is flexible and knows their job by heart.**”**

As a result, the strategies that were mentioned by at least **eight of the participants** and are employed by them before, during, and after disruptions take place involving:

- Data analysis
- Collaboration
- communication and information sharing
- knowledge management

3.4.7 Expert’s most critical strategies to enhance supply chain resilience

Finally, to align with the last objective of the qualitative research, which is to identify the most critical practices for the supply chain participants for enhancing supply chain resilience, each interviewee was given a list of all strategies resumed from the literature as mentioned in Annexe 2, to select five most important practices.

All of the experts unanimously chose collaboration as the preferred approach. After each selection, they were asked why, and the answer was almost always the same: Collaboration fosters stakeholder communication, promotes collective work, and helps address challenges while enhancing the supply chain's resilience.

Secondly, ***integration*** was selected **by six participants** that underscored its essential role in the supply chain, noting gaps in its implementation within their supply chains because coordinating the activities of the supply chain, they explained, allows better visibility and interconnected workflow and makes processes more efficient and more manageable.
Thirdly, six participants identified data analytics as a critical strategy that helped in all the supply chain resilience phases.
Finally, **knowledge management** and **flexibility** were selected by 4 participants; the rest of the strategies were mentioned a maximum of 2 times in total, which is why they were excluded from the results.

3.5 Discussion and conclusion

This chapter aimed firstly to determine the practices and strategies employed by supply chain experts to enhance the supply chain resilience across all phases of disruptions. The results showed that the ten participants revealed various strategies, which were already discussed in previous literature, for example, data analytics, knowledge management, redundancy, agility, collaboration, information sharing, flexibility, integration, Ambidexterity, trust (Agrawal & Jain, 2021), effective communication, appropriate supplier selection, diversification, contingency plan, robustness, visibility, (Adobor & McMullen, 2018; Tukamuhabwa et al., 2015) and new strategies were introduced by the experts such as buffer stock, restoration of relationships, transparency and cross training.

- **buffer stock,** also known as safety stock, was highlighted only by participants directly affected by supplier-related challenges. The experts underscored it as a proactive practice to face supplier issues or demand fluctuations. It is often used in the preparation phase.
- **restauration of relationships:** This strategy can be employed for the interviewee when trust is no longer ensured; it is a tool to rebuild trust and strengthen the relationships to ensure smoother operations and better communication. According to them, it is used more in the response and adaptation phase.
- **transparency** was highlighted by one participant who mentioned it as a helpful practice to foster trust between the clients and the company when a disruption happens, allowing for reactive measures to be taken in response.
- **cross training**, this last practice, was introduced by multiple participants who highlighted its importance in reducing vulnerabilities and minimizing reliance on a single team member, significantly enhancing flexibility when a disruption occurs. Moreover, according

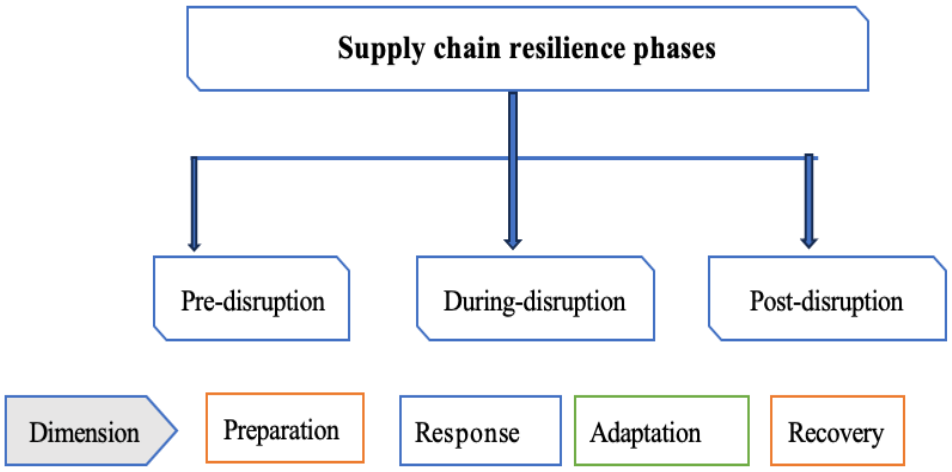
to their different point of view, it can be implemented in all phases of supply chain resilience.

Secondly, the other objective of conducting this qualitative study was to compare the conceptualization of supply chain resilience in the literature and the experts' perspectives and frameworks related to supply chain resilience. The results involved some commonalities because all the study participants defined supply chain resilience using terms in the literature, such as adaptability, response, preparation, agility, and learning from past experiences. However, some participants also included risk management as a component of supply chain resilience, which is not uncommon as the two concepts are closely related and often interdependent.

Thirdly, this study aimed to determine and compare the most important strategies with previous research. As stated in prior literature (Jüttner & Maklan, 2011; Kamalahmadi et al., 2022; Ponis & Koronis, 2012; Shekarian et al., 2020; Tukamuhabwa et al., 2015), specific strategies hold more significance and are particularly critical. These four strategies are flexibility, collaboration, agility, and redundancy. Based on the interviews, the most crucial strategies were identified as collaboration, data analytics, integration, knowledge management, and flexibility.

The final objective of this thesis was to develop a model of strategies for enhancing supply chain resilience in the face of adversity based on theoretical and empirical findings. After comparing the theoretical and interview data, the framework was adjusted to incorporate new elements and remove others. Once this was done, the updated framework was shared with six available experts for validation and confirmation, as shown in Figure 13.

Figure 13 :Validated model of supply chain resilience



strategies	Preparation	Response	Adaptation	Recovery	
Collaboration and coordination	X	X	X	X	Enduring strategies
Communication and information sharing	X	X	X	X	
Data analytics/ forecasts	X	X	X	X	
Knowledge management	X	X	X	X	
Flexibility	X	X	X		Pro-reactive strategies
Redundancy	X	X			
Buffer stock	X	X			
Transparency and visibility		X	X		reactive strategies
Agility		X	X		
Robustness			X		
Efficiency		X	X		
Trust			X	X	
Restauration of relationships				X	
Cross trainings	X				Proactive strategies
Contingency plans	X				
Diversification	X				

Source: Autor's own creation

RECOMMENDATIONS

The findings and conclusions of the study suggest that there is a recommendation for future researchers to conduct quantitative research in order to further enhance the existing qualitative findings. This can be achieved by addressing more questions to a larger population, which will help in validating and expanding the developed framework beyond the initial expert validation. In other words, the study recommends conducting more extensive research that encompasses a larger sample size, providing more comprehensive results and insights.

It is also recommended that the study should seek broader validation across diverse industry sectors or engage a larger panel of experts for a more comprehensive evaluation. This will help to ensure that the findings are not limited to a specific industry or group of experts and that they are applicable across different domains.

Moreover, organizations are advised to actively implement and test the identified strategies to ensure their effectiveness. This will enable organizations to evaluate the strategies' effectiveness and make adjustments where necessary.

It is important for organizations to monitor and track their progress toward achieving their objectives and goals to ensure that they are moving in the right direction. By doing so, organizations can make data-driven decisions and improve their resilience over time.

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ANNOTATION

This thesis is presented in three parts. The first part explores the concepts of organizational and supply chain resilience, analyzing existing frameworks and identifying gaps for a more comprehensive model.

The second part presents the methodology of research in detail, outlining the research strategy, sampling techniques, data collection, and analysis methods that were employed. This facilitated empirical validation of the proposed model.

The third part is presented as an analytical section, where practical implications are revealed through empirical analysis and interpretation. Novel strategies are introduced, and the proposed model is confirmed, offering application areas for developing supply chain resilience.

The work concludes by summarizing the findings and outlining recommendations for future research and practitioners. This contributes a comprehensive perspective on enhancing supply chain resilience.

Keywords: supply chain resilience, management of supply chain resilience, organizational resilience, resilient supply chain strategies

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ANOTACIJA

Ši disertacija pateikiama trijose dalyse. Pirmoji dalis nagrinėja organizacinės ir tiekimo grandinės atsparumo sąvokas, analizuodama esamus modelius ir identifikuodama spragas siekiant sudaryti išsamesnį modelį.

Antroje dalyje išsamiai pateikiama tyrimo metodologija, aprašant tyrimo strategiją, imties pasirinkimo technikas, duomenų rinkimo ir analizės metodus, kurie buvo naudojami. Tai leido empiriškai patikrinti pasiūlytą modelį.

Trečioji dalis pateikiama kaip analitinė sekcija, kurioje per empirinę analizę ir interpretaciją atskleidžiamos praktinės išvados. Įdiegtos naujos strategijos, patvirtintas siūlomas modelis, siūlant taikymo sritis plėtoti tiekimo grandinės atsparumą.

Darbas baigiasi išvadomis, kurios apibendrina išvadas ir nurodo rekomendacijas ateities tyrimams ir praktikams. Tai suteikia išsamų požiūrį į tiekimo grandinės atsparumo stiprinimą.

Raktažodžiai: tiekimo grandinės atsparumas, tiekimo grandinės atsparumo valdymas, organizacinis atsparumas, atsparių tiekimo grandinės strategijos

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SUMMARY

The recent disruptions, such as the Russia-Ukraine war, the COVID-19 pandemic, and geopolitical instability, have exposed the fragility of global supply chains. These disruptions have threatened the stability of supply chain operations, highlighting the need for comprehensive supply chain resilience management and development and how it is crucial to respond effectively to challenges and adapt to uncertainties more efficiently to avoid non-vulnerability of supply chains. However, during the examination of studies on the management of supply chain resilience and its development, researchers have confirmed that there is a lack of a unified approach. consequently, the thesis aims to identify the theoretical interpretations that form the basis of the concept of a resilient supply chain, explore the methodologies that can be applied to manage and strengthen resilience in supply chains, and propose a model that identifies the strategies to enhance resilience in the supply chains. Also, the novelty was based on attempt to validate the benefits of resilience to reduce the impact of crises on supply chains by presenting the latest scientific literature based on the developed methodological approach for the management and development of resilient supply chains.

Chapter one provided readers with a foundational understanding of organizational resilience and supply chain resilience. The chapter also highlighted the gaps in existing research and the need for comprehensive and well-established models. Several researchers, including (Adobor & McMullen, 2018; Christopher & Peck, 2004; Piprani et al., 2020), have pointed out this need. also, one of the main missing points with existing models is that they lack practical understanding. Furthermore, some authors provide vague definitions that are open to different interpretations. Chapter one ended by proposing a new model a new model which suggested strategies to enhance resilience in supply chains. These strategies were gathered from recent literature, and a new category of strategies was introduced. However, to validate this model, it needed to be compared to the real situation in companies. Therefore, three different industries in three different countries (Lithuania, Morocco, and Saudi Arabia) were chosen for qualitative research using semi-structured interviews. The purpose of these interviews was to explore how experts with a high level of resilience understand supply chain resilience and discover their practices to enhance it. The qualitative results helped build a new understanding of the actual

situation regarding supply chain resilience development and the strategies employed before, during, and after disruptions. New practices were discovered during the interviews, such as cross-training, restoration of relationships, and transparency. The positioning of when to use each strategy was modified depending on the interviewee's responses, and the new validated framework was confirmed.

it is still recommended for future researchers to conduct quantitative research in order to further enhance the existing qualitative findings. and conducting more extensive research that encompasses a larger sample size, providing more comprehensive results and insights.

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SANTRAUKA

Neseniai įvykę sutrikimai, tokie kaip Rusijos-Ukrainos karas, COVID-19 pandemija ir geopolitinė nestabilumas, atskleidė pasaulinių tiekimo grandinių pažeidžiamumą. Šie sutrikimai grėsė tiekimo grandinių operacijų stabilumui, pabrėždami poreikį kruopščiai valdyti ir plėtoti tiekimo grandinių atsparumo valdymą, kuris yra esminis efektyviam reagavimui į iššūkius bei pritaikymui neapibrėžtumams efektyviau, siekiant išvengti tiekimo grandinių pažeidžiamumo. Tačiau tyrinėjant studijas apie tiekimo grandinių atsparumo valdymą ir jo plėtrą, mokslininkai patvirtino vieningo požiūrio nebuvimą. Dėl šios priežasties disertacija siekia nustatyti teorines interpretacijas, kurios sudaro atsparios tiekimo grandinės sąvokos pagrindą, ištirti metodologijas, kurias galima taikyti valdyti ir sustiprinti atsparumą tiekimo grandinėse, bei pasiūlyti modelį, kuris identifikuotų strategijas atsparumui tiekimo grandinėse didinti. Be to, naujumas grindžiamas bandymu patvirtinti atsparumo naudą mažinant krizių poveikį tiekimo grandinėms, pristatant naujausią mokslinę literatūrą, grindžiamą sukurtu metodologiniu požiūriu atsparių tiekimo grandinių valdymui ir plėtrai.

Pirmasis skyrius suteikė skaitytojams pagrindinį organizacinio atsparumo ir tiekimo grandinės atsparumo supratimą. Skyriuje taip pat buvo pabrėžtos esamos tyrimų spragos ir poreikis išsamiam bei gerai įsisąmonintam modeliui. Keliose studijose, įskaitant (Adobor & McMullen, 2018; Christopher & Peck, 2004; Piprani et al., 2020), buvo paminėta ši poreikio aktualizacija. Be to, viena iš pagrindinių esamų modelių trūkumų yra praktinis supratimas. Be to, kai kurie autoriai pateikia neaiškias apibrėžtis, kurios yra atvirose interpretacijose. Pirmasis skyrius baigėsi pasiūlydama naują modelį, kuriame buvo siūlomos strategijos atsparumui tiekimo grandinėse didinti. Šios strategijos buvo surinktos iš naujausios literatūros, ir buvo pristatytas naujas strategijų kategorijos variantas. Tačiau norint patvirtinti šį modelį, reikėjo jį palyginti su realia padėtimi įmonėse. Todėl kokybiniam tyrimui, naudojant pusiau struktūruotus interviu, buvo pasirinktos trys skirtingos pramonės šalyse (Lietuvoje, Maroke ir Saudo Arabijoje). Šių interviu tikslas buvo ištirti, kaip ekspertai, turintys aukštą atsparumą, supranta tiekimo grandinės atsparumą ir atrasti jų taikomas praktikas, siekiant jį didinti. Kokybiniai rezultatai padėjo suformuoti naują supratimą apie faktinę padėtį, susijusią su tiekimo grandinių atsparumo plėtra ir naudojamomis strategijomis prieš, per ir po sutrikimų. Interviu metu buvo

atrastos naujos praktikos, tokios kaip kryžminis mokymas, santykių atkūrimas ir skaidrumas. Kiekvienos strategijos naudojimo pozicionavimas buvo modifikuotas priklausomai nuo interviu dalyvių atsakymų, ir naujas patvirtintas pagrindinis modelis buvo patvirtintas.

Vis tiek būtina ateities tyrėjams atlikti kiekybinius tyrimus, siekiant toliau sustiprinti esamus kokybinius rezultatus, ir atlikti plačiau apimantį tyrimą, apimančią didesnį imties dydį, suteikiant platesnius rezultatus ir įžvalgas.

ANNEXES

Annexe 1: author's definitions for supply chain resilience

Authors	Definitions of supply chain resilience	Core elements
Ponomarov & Holcomb (2009) p131	"**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".	Adaptive capability preparation, Response, recovery, connectedness
Tukamuhabwa et al (2015) p5599	"SCRES can be assessed on four aspects – **preparation** for a disruptive event; **response** to an event; **recovery** from the event; and, **growth/competitive advantage** after the event – while SCRES strategies or capabilities should aim to ensure these aspects are maximized in a timely way and at minimum cost. In addition, the capability to **adapt** underpins these four aspects"	Preparation, response, recovery, growth, competitive advantage, adaptation
Datta et al. (2007) (p.1393)	"Supply chain resilience is a **dynamic process** of steering the actions so that the organization always stays out of danger zone, and if the disruptive/uncertain event occurs, resilience implies initiating a very **rapid** and **efficient response** to minimize the consequences and maintaining or **regaining a dynamically stable** state, which allows it to **adapt** operations to the requirements of the changed environment before the competitors and succeed in the long run".	Dynamic capability, quick response, efficient response, adaptation, recovery
(Christopher & Peck, 2004) p2	"SCRES is the ability of the supply chain to **return to its original state** or move to a new, more desirable state after being disturbed"	Restorative ability
(Yao & Fabbe-Costes, 2018) p260	"Resilience is a **complex, collective, adaptive capability** of organizations in the supply network to maintain a **dynamic equilibrium**,	Complexity, collective capability, adaptive capability, dynamic

	react to and **recover** from a disruptive event, and to regain performance by **absorbing** negative impacts, **responding** to unexpected changes, and capitalizing on the **knowledge** of success or failure".	capability, recovery, absorptive capacity, response, knowledge capital
(Sadeghi et al., 2021) p377	"Resilience supply chain is defined as **the ability to return** to its original state or move to a more desirable situation, after experiencing problems and avoiding the occurrence of more critical issues".	Restorative ability
(Sarkar et al., 2022) p611	"Resilience is known as **recovery** and **elasticity** and the ability to **react** to external changes. A resilient strategy is implemented to reduce the damaging effects of a disruptive event. The goal is to minimize the time and cost requirements of recovery to **spring back** to the level of performance before the crisis occurs."	Recovery, elasticity, reaction, reverse capacity
(Adobor & McMullen, 2018) p1452	"Resilient supply chains have the capabilities to **respond**, **recover** and **transform** after a disruption".	Response capability, recovery, readiness(preparedness)
(Holgado & Niess, 2023) p3	"Earlier definitions were strongly focused on **response** (during disruption phase) and **recovery** (post-disruption phase), while **preparation** (pre-disruption phase) and the possibility of **growth** through opportunities (post-disruption phase) were emphasized afterwards"	Response , recovery , preparation , growth
(Gunasekaran et al .2015) p6811	"When defining supply chain resilience, "Business entities' ability to **anticipate** the impact would be a valuable skill set if they are to **respond** and **recover** within a short span of time	Anticipation , response recovery ,

	until the next major event will distinguish the high-performance businesses from the rest".	
(Piprani et al., 2020) p2538	"The notion of supply chain resilience is not new. In fact, firms are considering supply chain resilience as a way of dealing with vulnerabilities in the supply chain as it enables them to **readily prepare**, **adapt** and **respond** to unforeseen events".	Preparedness, readiness, Adaptation, response

ANNEXE 2: INTERVIEW GUIDE

Background information:

Q1: Can you please describe your role and responsibilities within your organization?

Q2: How long have you been working in your department?

General understanding of supply chain resilience.

Q3: Based on your experience, what types of disruptions (unexpected events or changes that interrupt the normal flow of goods, services, or information) have you encountered in your supply chain operations?

Q4: How would you describe or define supply chain resilience?

Effectiveness of enduring strategies

"Preparation phase"
Q5: could you provide specific examples of initiatives or strategies that have proven to be effective **in preparing** for disruptions in your organization?

"Responding phase"
Q6: Similarly, could you provide examples of strategies that were successful **in responding** to disruptions during their occurrence?

"Adaptation phase"
Q7: Could you highlight specific strategies that were implemented **to adapt** your operations to the requirements of the changed environment?

"Recovering phase"
Q8: Similarly, could you provide examples of strategies that were successful **in recovering** from disruptions?

Critical practices for enhancing Supply chain resilience:

Q8: What would you consider to be **the 5 best practices** from these strategies or perhaps the most critical ones, for improving and enhancing supply chain resilience?

Flexibility	**Collaboration** (between the participants of supply chain and employees)	**Agility** (quick Adaptation to changes)
Redundancy (backup Systems)	**Efficiency**	**Information sharing**
Visibility	**Trust**	**Data analytics**
Velocity (Quick Response)	**Risk management**	**Knowledge management**
Diversification (variety of solutions)	**Robustness** (the capacity to handle stress and disruptions without being severely affected)	**Integration** (coordination of all activities)
Ambidexterity (Balancing the exploitation of existing resources and capabilities with **innovation)**		