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**Supply chain optimization and external factors**

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## ABSTRACT

This thesis investigates the profound transformation of global supply chains in response to exogenous shocks, such as geopolitical conflicts, pandemics, and natural disasters.

The central theme addressed is the vulnerability of supply chains with regard to these unpredictable factors, as highlighted by the COVID-19 pandemic and the ongoing Russian-Ukrainian war. The study first identifies the need to implement and improve visibility, adaptability, and risk management in supply chains, both to ensure business continuity in a changing operating environment and to increase competitiveness through more efficient, resilient structures. Through a combination of reviews of relevant scientific literature and interviews with industry experts, this thesis presents key insights into strategies for building resilient supply chains.

In particular, emerging technologies such as blockchain, AI, and IoT for real-time monitoring and predictive risk management are explored, and the importance of developing strong partnerships with suppliers is emphasized. The originality of this study lies in its holistic approach, combining theoretical models with practical insights from practitioners, bridging the gap between academic research and operational realities. Methodologically, the research is based on a qualitative analysis of interviews with experts, complemented by a comprehensive review of the current literature on supply chain risk management (SCRM). Key trends such as the rise of green supply chain practices and the integration of new technologies are explored, with a focus on implementation challenges.

The findings demonstrate the critical need for proactive risk management strategies and the integration of advanced technologies to enhance supply chain resilience. These findings are not only relevant in the current volatile environment, but also suggest future directions for research and practice. The study concludes that although current tools and methods are promising, significant improvements in technology adoption and staff training are needed to realize their full potential. Future studies should focus on the scalability of these solutions and the role of sustainability in long-term supply chain strategies.

## INTRODUCTION

The basis of this thesis is to study the effects of the impact of exogenous events on supply chains and to analyse the tools and best practices available to companies to optimise these structures and make them more resilient to instabilities in the operational and market environment.

The increasing complexity of global supply chains has resulted in a growing vulnerability to exogenous shocks, such as geopolitical tensions, pandemics and natural disasters. Recent events, including the COVID-19 pandemic and the Russian-Ukrainian conflict, have highlighted these weaknesses, demonstrating how traditional supply chain management models are inadequate in an increasingly unstable global environment. Traditional supply chains rely on predictable market conditions and operational stability, making them vulnerable to external disruptions<sup>1</sup>. Although numerous studies have emphasised the importance of risk management in supply chains<sup>2</sup>, there remains a significant gap in exploring the integration of emerging technologies such as blockchain, artificial intelligence (AI) and the Internet of Things (IoT) in predictive management and real-time risk monitoring<sup>3</sup>.

Furthermore, while some studies have focused on individual risk management strategies<sup>4</sup>, and others have examined the benefits of advanced technologies to improve visibility in supply chains<sup>5</sup>, there is a lack of a holistic approach that combines the use of these technologies with a strategic vision that can increase resilience against exogenous shocks in a volatile and unpredictable environment. This lack of integrated studies represents a significant research gap that this work aims to fill.

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<sup>1</sup> Neil Chueh-An Lee. (2021). *Reconciling integration and reconfiguration management approaches in the supply chain*. International Journal of production economics. Vol. 242 ; D. Ivanov, A. Dolgui. (2020) *Viability of intertwined supply networks: extending the supply chain chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak*. International Journal of Production Research. Pp 2904-2915.

<sup>2</sup> Wagner, S.M. and Bode, C. (2008), An empirical examination of supply chain performance along several dimensions of risk, Journal of Business Logistics, Vol. 29 No. 1, pp. 307-325 ; Tang, C.S. (2006). *Perspectives in supply chain risk management*. International Journal of Production Economics. Vol. 103 No. 2, pp. 451-488.

<sup>3</sup> T.J. Pittet, J. Fiksel, K.L. Croxton. (2011) *Ensuring Supply Chain resilience: development of a conceptual framework*. Journal of Business Logistic. Volume 31, Issue 1.

<sup>4</sup> D. Ivanov, J. Blackhurst, A. Das. (2021). *Supply chain resilience and its interplay with digital technologies: making innovations work in emergency situations*. International Journal of Physical Distribution & Logistic Management. Pp 97-102.

<sup>5</sup> D. Ivanov, A. Dolgui. (2020) *Viability of intertwined supply networks: extending the supply chain chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak*. International Journal of Production Research. Pp 2904-2915.

The main gap that this thesis aims to address concerns the limited understanding of how advanced technologies - such as blockchain, artificial intelligence and IoT - can be effectively integrated into supply chain management to increase resilience against exogenous disruptions. While current research focuses mainly on specific strategies, there is a paucity of studies exploring the practical application of these technologies in a complex, global framework that requires adaptability and real-time visibility<sup>6</sup>. The aim of this thesis is therefore to explore the integration of these advanced technologies to provide a practical and theoretical framework that enables companies to improve their ability to adapt to the challenges imposed by exogenous shocks.

To fill this gap, the following research questions guide the study:

1. How can the integration of advanced technologies such as AI, IoT and blockchain improve the resilience of global supply chains against exogenous shocks?
2. What are the current limitations in the application of these technologies and how can companies overcome these challenges?
3. What best practices can companies adopt to strengthen their risk management strategies in an increasingly volatile global environment?

To answer these questions, the research adopts a mixed methodology that combines literature review with interviews with industry experts. The literature review includes scholarly articles published in the last twenty years that address topics related to supply chain risk management, technology integration and operational resilience. Publications offering an overview of emerging technologies and their practical implementation were selected<sup>7</sup> in order to identify trends and gaps in the literature.

In parallel, semi-structured interviews were conducted with a sample of industry experts, chosen for their experience in supply chain management and the adoption of emerging technologies. The sample included managers from one of the largest international consulting firms, specialising in mapping and redesigning

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<sup>6</sup> D. Ivanov, A. Dolgui. (2020) *Viability of intertwined supply networks: extending the supply chain chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak*. International Journal of Production Research. Pp 2904-2915. ; Christopher M. (2005). *Supply Chain Management. Creare Valore con la Logistica*. Financial Times, Prentice Hall.

<sup>7</sup> Wagner, S.M. and Bode, C. (2008). *An empirical examination of supply chain performance along several dimensions of risk*. Journal of Business Logistics, Vol. 29 No. 1, pp. 307-325 ; Tang, C.S. (2006). *Perspectives in supply chain risk management*. International Journal of Production Economics. Vol. 103 No. 2, pp. 451-488. ; Neil Chueh-An Lee. (2021). *Reconciling integration and reconfiguration management approaches in the supply chain*. International Journal of production economics. Vol. 242 ; D. Ivanov, A. Dolgui. (2020) *Viability of intertwined supply networks: extending the supply chain chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak*. International Journal of Production Research. Pp 2904-2915.

the processes that make up supply chains and applying these new technologies in improving business performance and operational capabilities. During the interviews, topics such as the practical application of advanced technologies, challenges encountered and effective strategies to improve the resilience of supply chains were discussed. The qualitative data collected was analysed using textual analysis software to identify recurring themes and classify the results into key categories.

This mixed methodology allows for the integration of theoretical knowledge derived from the literature with practical experience provided by experts, offering a comprehensive and applicable view of the challenges and opportunities related to technology integration in supply chains.

The thesis is divided into four main chapters. The first chapter introduces the concept of supply chains and provides a historical and structural contextualisation, which is useful for understanding the vulnerabilities of current supply chain structures. The second chapter focuses on the classification of exogenous risks and the analysis of global threats to supply chains, with particular reference to the COVID-19 pandemic. The third chapter delves into the optimisation of supply chains through the mapping and integration of advanced risk management technologies. Finally, the fourth chapter presents the results of the survey conducted, including thematic analyses from the interviews and practical implications for companies.

This thesis contributes to filling an important gap in the existing literature by providing an integrated picture of how emerging technologies can improve the resilience of global supply chains. The research findings offer useful insights for business practice, stimulating a debate on the adoption of advanced technologies as a strategic tool to address future global challenges. The findings provide practical guidance for companies aiming to improve their operational resilience by reducing exposure to exogenous risks and optimising their response capabilities.



## CHAPTER ONE

### Supply chains in the international economic landscape

#### 1.1 Introduction to the supply chain concept

The supply chain is a crucial element in the operation of modern companies. In recent decades, this concept has gained increasing relevance, reflecting the evolution of business models and management strategies. The supply chain is no longer merely a series of logistics operations but a complex system involving multiple players and processes, all aimed at meeting customer needs efficiently and effectively. It has become one of the backbones of business operations, assuming a strategic role with a direct impact on both customer experience and corporate profitability. Consequently, many companies have established a dedicated function for the unified management of this vital process.<sup>8</sup>

The main definitions of supply chain focus on the determinants of an effective supply chain. These definitions imply the need for a source and destination between which goods flow. Generally, supply chains begin with resources (raw materials), combine a series of value-creating activities, and end with the transfer of a finished product to consumers. Some of the supply chain definitions adhering to these principles are:

- Beamon B. (1998): "a structured production process in which raw materials are transformed into finished goods, then delivered to end customers."
- Bridgefield Group (2006): "a connected set of resources and processes that begins with the procurement of raw materials and expands through the delivery of finished goods to the final consumer."
- Pienaar W. (2009b): "a general description of process integration involving organizations to transform raw materials into finished goods and transport them to the end user."

Some definitions, such as those by Little, A. (1999), Chow, D., and Heaver, T. (1999), and Ayers, J. B. (2001), extend the supply chain concept to include information flows and additional activities such as logistics management. The differences between the definitions reflect variations in focus and scope, making a unified supply chain definition difficult. Nevertheless, for the purpose of this thesis paper, it is

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<sup>8</sup> Riva L. (2020). *La supply chain, un processo strategico che richiede una funzione ad hoc*. Il Sole 24 ore.

agreed that the role of the supply chain is to add value to a product by transporting it from one location to another, even if the product undergoes transformation in the process.<sup>9</sup>

## 1.2 Historical evolution of supply chain concept

Defining logistics is a complex challenge due to the wide range of contributions and studies by academics and experts in the field. Over time, logistics has become increasingly relevant, establishing itself as a crucial business function on par with marketing, sales, and management control. Although the roots of logistics are ancient, it is only since the 1950s that it has been recognized not only as a military tool but also as a strategic business tool.

Historically, logistics in wars involved organizing the procurement and transportation of military materials, essential for ensuring victory. A significant example is the British defeat in the American War of Independence, caused mainly by inadequate logistical organization to supply troops thousands of miles away.<sup>10</sup>

While armies have long understood the importance of logistics, businesses have only recently begun to recognize its value. In the 1960s, logistics was seen primarily as the distribution of finished products, focusing mainly on transportation from the warehouse to the customer. Around 1975, companies began exploring improvements in the physical distribution of products, seeking to optimize the distribution cycle.

In the 1980s, with the introduction of new management approaches such as Just-in-Time (JIT) and Materials Requirements Planning (MRP), the focus shifted to materials management, giving rise to the concept of "materials logistics." This phase emphasized optimizing activities related to the acquisition, handling, and coordination of materials to ensure a constant supply for production and other business functions.

In the 1990s, the concept of logistics shifted further from purely internal company management to integrated logistics. This approach, highlighted by the Council of Logistics Management in 1986, viewed logistics as a cross-functional process integrated with other supply chain players. Disruptive factors such as the Internet and globalization contributed to the emergence of increasingly complex and

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<sup>9</sup> Javier A. (2012). *A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective*. Glorious Sun School of Business and Management. Donghua University.

<sup>10</sup> Christopher M. (2005). *Supply Chain Management. Create Value con la Logistica*. Financial Times, Prentice Hall.

interconnected business organizations, transforming the global logistics landscape into a network model involving collaboration with subcontractors, distributors, and trading partners worldwide.<sup>11</sup>

Finally, the concept of Supply Chain Management (SCM) represents the latest evolutionary stage. Companies now recognize that improving logistics requires the involvement of external stakeholders. Business success depends on the effective management of the entire supply chain, where the company is part of a network of organizational entities integrating their processes to deliver value to the customer. Global players like Amazon are shaping new paradigms, making the supply chain a key competitive and strategic lever in their customer satisfaction-focused business model. Even in traditionally non-critical industries like telecommunications, more companies are creating functions dedicated to the end-to-end management of this vital process to maximize customer satisfaction and reduce overall costs.

### **1.3 Supply Chain Management (SCM) and the SCOR model**

Supply chain management (SCM) is fundamental for any enterprise engaged in the production or marketing of products, services, information, events, or projects. In today's interconnected business environment, no enterprise operates in isolation. Instead, they are part of a network of interdependent enterprises united by the common goal of satisfying customer needs. This network, known as the supply network, includes not only direct customers and suppliers but also the customers of customers and suppliers of suppliers. Understanding the principles that govern the management of processes within these supply networks is key to business success.

The concept of supply chain management originated in 1982 and was first defined in Oliver and Weber's work *Supply Chain Management: Logistics Catches Up with Strategy*. Initially, SCM referred to techniques aimed at reducing inventory within a company and across a supply chain interconnected by customer-supplier relationships. Over time, SCM has evolved to focus on both upstream relationships with suppliers and downstream relationships with the distribution system and end customers.<sup>12</sup>

Effective supply chain management offers numerous competitive advantages. According to Christopher (2016), a well-managed supply chain positively impacts market responsiveness, reduces operating costs,

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<sup>11</sup> Camporese A. (2013). *La Gestione Strategica del Supply Chain Management: l'articolato caso Dell Inc.*. Corso di Laurea Magistrale in Economia e Gestione delle Aziende.

<sup>12</sup> Oliver, R. Keith, and Michael D., (1982) *Webber, Supply-chain management: logistics catches up with strategy*. Outlook 5.1: 42-47

and improves customer services. Companies can reduce costs related to production, transportation, and inventory management through process optimization and waste elimination. Quality and flexibility are key elements in SCM. Quality management throughout the supply chain ensures that final products meet customer expectations, reducing return rates and increasing customer satisfaction. Flexible supply chains can quickly adapt to market demand changes, improving a company's ability to respond to new opportunities and threats (Swafford, Ghosh, and Murthy, 2008). Effective SCM can thus transform from a managerial factor with no added value to a source of competitive advantage.<sup>13</sup>

Despite the benefits, SCM presents several challenges. Increasing globalization of supply chains adds complexities such as managing cultural differences, regulations, and international logistics. External pressures, like environmental concerns and sustainability issues, have grown, pushing companies to balance economic goals with environmental and social responsibilities. Understanding the operating environment from sociopolitical, cultural, and geographic perspectives is crucial for risk management, aiming to minimize negative impacts of external factors. This thesis will explore risk classification, threat analysis, and supply chain risk management tools in detail. New technologies like IoT, blockchain, and AI play a key role due to their predictive capabilities and process integration, though they require significant investments and skills, potentially impacting short to medium-term revenue.<sup>14</sup>

To address challenges and maximize benefits, companies can adopt several best practices in SCM. These practices fall into four macro areas. First, close collaboration with suppliers, logistics partners, and customers enhances visibility and coordination along the supply chain, improving costs, flexibility, and product delivery.<sup>15</sup> Second, implementing advanced technologies such as SCM systems, ERP, and big data analytics improves management and cost efficiency.<sup>16</sup> Third, adopting sustainable practices, such as responsible sourcing and reducing carbon emissions, not only satisfies customers but can also enhance market share by avoiding unethical behavior that may lead to public boycotts. Lastly, developing risk management strategies, like supplier diversification, safety stock creation, and business continuity plans, can mitigate the negative effects of disruptions.<sup>17</sup>

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<sup>13</sup> Christopher, M. (2016). *Logistics & Supply Chain Management*. Pearson UK.

<sup>14</sup> Hult, G. T. M., Ketchen, D. J., & Slater, S. F. (2004). *Information processing, knowledge development, and strategic supply chain performance*. *Academy of Management Journal*, 47(2), 241-253.

<sup>15</sup> Chopra, S., & Meindl, P. (2013). *Supply Chain Management: Strategy, Planning, and Operation*. Pearson.

<sup>16</sup> Flynn, B. B., Huo, B., & Zhao, X. (2010). *The impact of supply chain integration on performance: A contingency and configuration approach*. *Journal of Operations Management*, 28(1), 58-71.

<sup>17</sup> Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). *Defining supply chain management*. *Journal of Business Logistics*, 22(2), 1-25.

The Supply Chain Operations Reference (SCOR) model is a key tool for improving supply chain performance. Developed by the Supply Chain Council, the SCOR model provides a structured framework for addressing, improving, and communicating SCM decisions within a company and with its suppliers and customers. It integrates concepts like benchmarking, measurement, and reengineering, offering a comprehensive view of the processes required to meet customer demands. Its standardized assessments of supply chain efficiency and effectiveness help identify improvement areas. SCOR can be adopted by any company with a supply chain, regardless of the sector.

The SCOR model measures supply chain performance using three levels, enabling organizations to compare their performance with peers. It includes over 250 SCOR metrics related to agility, asset management efficiency, cost, reliability, and responsiveness. These metrics help establish supply chain requirements and identify areas for improvement.

1. *Planning*: Manages supply and demand balance, aligning the supply chain with the financial plan, and establishing business rules for efficiency.
2. *Sourcing*: Focuses on material acquisition and supply infrastructure, managing inventory, supplier agreements, and product verification.
3. *Production*: Covers manufacturing processes, packaging, storage, and release, as well as equipment, facilities, and transportation management.
4. *Delivery*: Manages order storage, transportation, customer orders, billing, asset management, export/import requirements, and product life cycles.
5. *Returns*: Handles returned items, defective products, and packaging, ensuring satisfactory customer service and regulatory compliance.
6. *Enabling*: Supports all SCM phases, ensuring compliance with business and regulatory standards through business rules, contracts, data, and performance management.

The SCOR model is a powerful tool providing a structured and standardized view of SCM. Its features enable organizations to improve performance through better understanding and management of internal and external processes. Its applicability across different sectors has made SCOR a benchmark for companies aiming to optimize their supply chains, driving operational improvement and efficiency by effectively responding to market demands.

Regardless of the SCM model used, effective SCM is crucial for success in a competitive global market. Effective SCM management leads to significant improvements in cost reduction, quality, flexibility, and

competitive advantage. Companies face challenges like globalization, risks, technology integration, and sustainability. By adopting best practices in collaboration, technology, risk management, and sustainability, companies can optimize their supply chain and ensure long-term success.<sup>18</sup>

#### **1.4 Supply chain; from local to global structures**

As emphasized in the preceding paragraphs, adapting organizational structures to the external environment is essential for ensuring operational efficiency. This adaptation is crucial to avoid missed opportunities, increased costs, and threats to the organization's survival. In this research context, supply chains (SCs) are classified into local or global markets based on their degree of internationalization, production strategies, and market positioning.

a. Local Supply Chains (Local SC):

Local SCs are characterized by activities conducted within national borders. Companies in this category focus on production expansion and customer specialization strategies. Production expansion involves maintaining excess capacity and forward integration. Concurrently, customer specialization aims at producing specialized products with proximity between suppliers and the central company. This proximity is vital for effective collaboration and rapid responses to domestic market needs.<sup>19</sup>

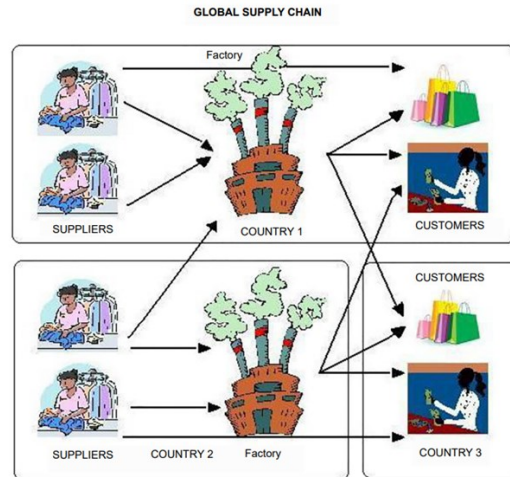
b. Global Supply Chains (Global SC):

Global SCs extend beyond local boundaries, involving multiple countries in the production process. These chains enhance competitiveness by seeking cost-effective supply sources outside the domestic market and backup solutions in case of local material shortages. Globalization encompasses all interconnected processes necessary for production, irrespective of geographic locations.

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<sup>18</sup> Motiso D. (2022). *What Is the SCOR Model? (With Definition and Components)*. Indeed.com.

<sup>19</sup> McDougall, P.P. (1989). *International versus domestic entrepreneurship: new venture strategic behavior and industry structure*. Journal of Business Venturing. Vol. 4 No. 6, pp. 387-400.



Source(s): Adapted from (Vidal and Goetschalckx, 1997)

Image 1: depiction of the structure of a global value chain (source: Thanh Pham H., Truong Quang H., Sampaio P., (2023). The impact of global risks on supply chain performance. An empirical study on construction sector in the COVID-19 pandemic. International Journal of Quality & Reliability Management. Pg. 3)

Technological innovations and trade deregulation are pivotal motivations for global sourcing and supply. Companies derive numerous benefits from global SCs, including cost reduction, increased profitability, and enhanced reliability through international production sources.

A compelling example demonstrating the efficacy of a global SC strategy involves Nokia Corporation. On March 17, 2000, lightning struck a power line in Albuquerque, New Mexico, causing a fire at a local Royal Philips Electronics factory. This incident damaged millions of microchips, affecting Nokia, a major customer of the factory. Nokia promptly redirected its orders to other Philips factories, as well as Japanese and U.S. suppliers. This multi-supplier strategy enabled Nokia to sustain production, mitigating the accident's adverse effects. In contrast, Ericsson, another customer of the factory, lacking alternative microchip sources, faced production interruptions for months, resulting in a loss of \$400 million in revenue. This case underscores the critical role of a global SC in risk mitigation and business continuity.<sup>20</sup>

Beyond cost and reliability advantages, global SCs offer competitive benefits such as access to inexpensive labor and raw materials, improved financing opportunities, larger markets, arbitrage opportunities, and investment incentives from host governments.<sup>21</sup> The primary objective of a global network is to provide clients with rapid and cost-effective access to resources, capabilities, and

<sup>20</sup> Chopra, S. and Sodhi, M. (2004). *Supply-chain breakdown*. MIT Sloan Management Review, Vol. 46 No. 1, pp. 53-61.

<sup>21</sup> Tang, C.S. (2006). *Perspectives in supply chain risk management*. International Journal of Production Economics. Vol. 103 No. 2, pp. 451-488.

supplementary competencies beyond the firm's core strengths, leveraging differentiation, outsourcing, knowledge exchange, and complementary capabilities.

However, despite their advantages, global SCs present significant uncertainties and risks. While they may reduce overall costs under stable conditions, the risk exposure increases due to interconnected links across a vast network of companies. These links are susceptible to disruptions, failures, macroeconomic shifts, political changes, and disasters, complicating management efforts. Moreover, diverse local cultures, languages, and practices can impact the effectiveness of SC management, particularly in demand forecasting and materials planning.

In conclusion, adapting organizational structures to the external environment is crucial for company success. Local and global SCs offer distinct advantages, but global SCs excel in terms of cost efficiency, reliability, and access to global resources. Nonetheless, they entail greater risks and uncertainties, necessitating robust risk management strategies. Companies must carefully balance these factors to optimize operations and sustain competitiveness in the global market.<sup>22</sup>

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<sup>22</sup> Thanh Pham H., Truong Quang H., Sampaio P., (2023). *The impact of global risks on supply chain performance. An empirical study on construction sector in the COVID-19 pandemic*. International Journal of Quality & Reliability Management. Pp. 2-5.



## CHAPTER TWO

### Supply chains in the international economic landscape

Economic risk has always been a part of human history, representing an inherent and inevitable element of business and financial activities. Since ancient times, businesses and individuals have faced uncertainties and potential losses related to various factors, such as natural disasters, political instability, market fluctuations and technological innovations. The need to limit the impact of such factors has spurred the development of capabilities to identify, assess and manage these risks, which are considered essential to survival and economic success.

The earliest thoughts on risk analysis, and in particular the study of probability understood as "an understanding of the rules governing the randomness of events," date back to antiquity and concerned issues of everyday life, gambling, and the natural and legal sciences. These primitive approaches and attempts to understand such phenomenology did not specifically aim to formulate theories or laws defining the concept. However, it was gambling that was the driving force behind a more in-depth study of probability as early as the late Middle Ages, a period when several scholars tried their hand at solving problems related to dice rolling and repeated games.

It was not until the 17th century, specifically 1654, that the current approach to probability theory was born, thanks to the correspondence between Fermat and Pascal, based precisely on studies concerning gambling.<sup>23</sup> From this time on, the study of risk is also extended and expanded to the field of economics in its modern forms and meanings, thus transforming the way of dealing with uncertainty in economic decisions.

One of the objectives of this thesis is to classify risks exogenous to firms that could have significant impacts on economic performance. In recent times, events such as the 2008 global financial crisis and the COVID-19 pandemic have further underscored the importance of economic risk management, highlighting how global dynamics can profoundly affect financial markets, national economies, and supply chains. The latter are a focus of this work both because of their strategic relevance and their high exposure to the endogenous factors.

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<sup>23</sup> Accordi P. (2002). *La Rivoluzione scientifica: i domini della conoscenza. La nascita del calcolo delle probabilità*. Enciclopedia Treccani. Fondo Treccani.

## 2.1 Brief mention of the origins of the second globalization

Since the 1980s there has been an economic and legislative phenomenon of deregulating financial markets and loosening trade constraints. In particular, the main actors of such neo-liberal policies were Ronald Reagan and Margaret Thatcher who implemented such policies based on the doctrine of Supply side economics, that is, a model of economic growth centered on easing the role of governments in the economic sphere with the aim of promoting prosperity that was essentially based on the efficiency of market mechanisms. It was precisely from this historical period, and fostered by the above-mentioned neo-liberal policies that we witnessed the phenomenon of the so-called "second globalization," which led to a strong acceleration in the integration of economies on a global scale. The deregulation of the 1980s thus facilitated globalization by reducing regulatory barriers and promoting a more open and competitive business environment. The combination of deregulation policies and technological innovations also created fertile ground for global corporate expansion and international economic integration.<sup>24</sup>

While this new phase of globalization has been supported by market deregulation policies, it has also been underpinned by two other key factors such as the development of major technological innovations and the conclusion of free trade agreements that have accrued since the 1990s. Among the best known are the North American Free Trade Agreement (NAFTA) of 1993, the European Single Market Agreement of 1993, and the General Agreement on Tariffs and Trade (GATT) of 1995. These agreements have had a significant impact on the second phase of globalization, as they have been credited with stimulating international trade by promoting cross-border investment and facilitating global economic integration. They have also reduced trade barriers, increased competitiveness and contributed to economic growth on a global scale, marking an era of intensified economic and trade cooperation among nations. In addition, the side of technological innovations, such as primarily the development of the Internet since the early 1990s and in general to increasingly high-performance communication and information systems have allowed both to reduce the time gap in the exchange of information and provided faster and more effective business support tools.

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<sup>24</sup> Pozzi S. (2022). *Il crollo della borsa di New York del 19 ottobre 1987 e l'evoluzione della legislazione finanziaria negli USA*. Universtà degli Sudi di Pavia. Pg. 15.

## 2.2 The role of global factories in expanding the Concept of Risk in the Global Supply Chain (SC)

The concept of the global factory is a central element for understanding the rationale and threats of global value chains. The research published by Peter J. Buckley in the Journal of World Business, titled "*The Impact of the Global Factory on Economic Development*,"<sup>25</sup> provides a comprehensive overview of the structure and foundational elements of this model, which represents a significant evolution in how multinational enterprises (MNEs) organize and manage their operations globally. The core idea of this new vision of MNE behavior lies in their new organizational structure, making them increasingly like a differentiated network.<sup>26</sup> More specifically, location and ownership policies are strategically selected to optimize costs and increase efficiency, without the obligation to internally control every stage of the production process. This approach allows MNEs to outsource or offshore activities that do not fall within their core competencies, resulting in a strategic outcome of being more flexible and responsive to global market dynamics. The ability to effectively coordinate and manage a global network of suppliers, producers, and distributors is essential for the success of this organizational model.

A feature of the global factory concept is the adoption of outsourcing and offshoring practices. Outsourcing involves choosing to "buy" rather than "do" internally, in line with Coase's (1937) theory of the decision to outsource or internalize. In other words, MNEs outsource non-strategic activities to specialized external suppliers, reducing costs and increasing operational efficiency. Offshoring, on the other hand, involves offshoring production activities abroad, combining the outsourcing option with the decision to produce in lower-cost countries<sup>27</sup>. These strategies allow MNEs to take advantage of global differences in labor costs, tax regulations, and logistical advantages.

In addition, MNEs have developed the ability to precisely segment ("fine slicing") their activities, adopting increasingly refined calculation to decide where and how to carry out each stage of the production process. This ability enables them to change location and internalization decisions for activities that were previously tied to other stages of production and could only be controlled through

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<sup>25</sup> Buckley, P. J. (2009). *The impact of the global factory on economic development*. Journal of International Business Studies. Pp. 133–142.

<sup>26</sup> Buckley, P. J., & Ghauri, P. N. (2004). *Globalisation, economic geography and the strategy of multinational enterprises*. Journal of International Business Studies, 35(2): 81– 98.

<sup>27</sup> Buckley, P. J., & Casson, M. C. (1976). *The future of the multinational enterprise*. London: Macmillan

centralized internal management. Fragmentation of the production chain may be accompanied by spatial disaggregation, particularly when in the different stages of the value chain<sup>28</sup> :

1. there are elements of technological discontinuity between the different stages
2. there are different intensities of factors used
3. coordination and transportation costs are sufficiently low

### *2.2.1 New Opportunities for New Places and Market Utilization by MNEs.*

For many emerging economies, the development and growth of the so-called global factories has been an opportunity to overlook and enter international business. Indeed, countries such as India and China have benefited greatly from this phenomenon, particularly since the first half of the 1990s, thanks to the phenomenon of subcontracting manufacturing and service activities from MNEs that own the brands. This trend has fostered and still fosters economic and industrial development in these regions, allowing them to integrate into global value chains. Access to cheap, affordable and trained labor for low-to-medium value-added activities, together with the development of logistics practices, has made these regions particularly attractive for offshoring and relocation activities. It should be highlighted, however, that while indeed emerging economies have benefited from integration into global value chains, at the same time precisely because of intensifying external competitive pressures they are facing significant challenges. In this regard, the literature on global value chains (GVCs) and global commodity chains offers important insights into the relationships between global value chains and the effects of globalization<sup>29</sup>. GVC analysis highlights the difficulties that emerging economies face in attempting to improve their positions within the global value chain by exploring the prospects for upgrading parts of the chain that benefit poorer economies<sup>30</sup>.

This approach then subjects each internalized activity to the "market test," i.e., the continual evaluation of the trade-off on whether it is worthwhile to keep them internal to the firm or not. The result is a differentiated network that optimizes overall operations by combining internalization and outsourcing in an efficient and flexible manner. In this context, information brokering, rather than production, becomes

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<sup>28</sup> Deardorff, A. (2001). *Fragmentation across cones*. In S. Arndt & H. Kierz-Kowski (Eds.), *Fragmentation: new production patterns in the world economy*. Oxford: Oxford University Press.

<sup>29</sup> Gereffi, G. (2001). *Beyond the producer driven/buyer driven dichotomy*. IDS Bulletin, 32(2): 30–40

<sup>30</sup> Barnes, J., Kaplinsky, R., & Morris, M. (2004). *Industrial policy in developing economies: Developing dynamic comparative advantage in the South African Automobile sector*. *Competition and Change*, 8(2): 153–172.

a key element of the global factory model, with the brand owner acting as an information broker between the manufacturer and the retailer<sup>31</sup>. Furthermore, the study "*Institutional economics and business history: A way forward? Business History*" highlights in this regard the importance of the role of Information and Technology (especially the development of blockchain technology and Industry 5.0, both of which will be explored later in this thesis paper) in the organizational structure of MNEs and the optimization of global value chain governance.

### *2.2.2 Governance of Global Value Chains and Shifting the Focus of Competition.*

Governance of global value chains is a crucial aspect of understanding the operation of the global factory. Several studies on the governance of GVCs<sup>32</sup> (Gereffi, Humphrey, & Sturgeon, 2005) have explored how MNEs manage the relationships between different stages of production and how governance decisions affect the structure of value chains. The transaction cost approach is used to explain both internalization and outsourcing of activities. Research has also identified different types of governance within GVCs, based on factors such as the complexity of information and knowledge transfer and the ability to encode that information. This thesis paper focuses precisely on the governance of exogenous risks, focusing the analysis on strategies to mitigate them across the whole GVC with the aim of making the whole system resilient.

The phenomenon of globalization has led, in conclusion and as highlighted in the previous chapter, to a sharp increase in competitive pressures for enterprises both local and operating at the supranational level. In order to remain competitive and not lose market share, they have focused their efforts on reducing operating costs by exploiting the operational advantages derived from the global value chain. This has effectively shifted the weight of competition from "enterprises-firms" to "supply chains-supply chains," consequently expanding the concept of risk and exposure to new threats.

## **2.3 Classification and types of exogenous risks**

Unpredictable and catastrophic events such as earthquakes, tsunamis, wars, acts of terrorism, economic and political instability, social and cultural problems, diseases such as COVID-19, and other natural and

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<sup>31</sup> Casson, M. (1997b). *Institutional economics and business history: A way forward?* *Business History*, 39(4): 151–171.

<sup>32</sup> Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). *The governance of global value chains. Review of International Political Economy*, 12(1): 78–104.

man-made disasters can severely disrupt a global supply chain. These adversities, though rare, can have a significant impact on supply chain performance, affecting the entire supply chain from upstream to downstream.

The study "The impact of global risks on supply chain performance. An empirical study on construction sector in the COVID-19 pandemic" presented a model depicting the exogenous risks that a global value chain could find itself facing.

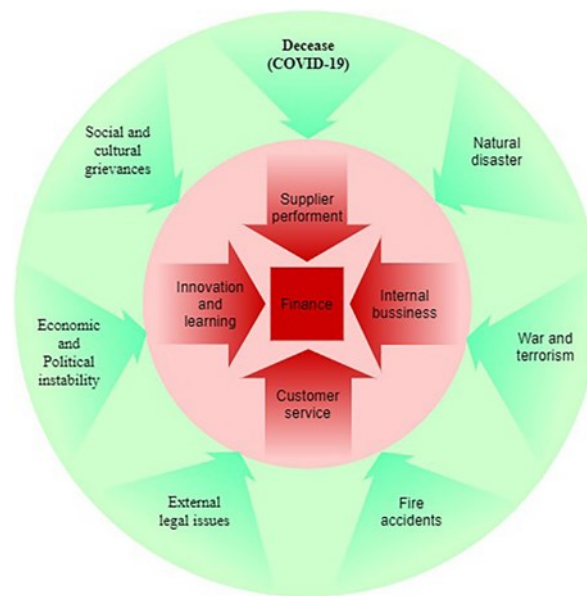


Image 2: the model in the image divides risks into seven clusters and highlights their ability to affect revenue-generating factors. (source: Thanh Pham H., Truong Quang H., Sampaio P., (2023). The impact of global risks on supply chain performance. An empirical study on construction sector in the COVID-19 pandemic. International Journal of Quality & Reliability Management. Pg. 6).

As shown in the image outside the circle and colored green, the different risk clusters that impact the output of the procurement process are depicted. The four macro-areas in red, on the other hand, represent the elements that have an impact on the firm's financial performance and thus relate to the firm's ability to generate value. The structure of this model highlights how exogenous factors have a significant and pivotal impact on business activities and that they pose a real threat to the competitiveness of the enterprise itself. It is important to highlight how costs, return on investment (ROI) and growth, are recognized as key performance indicators (KPIs) to assess SC efficiency. However, these measures tend to use historical and not prospective data in order to show the current state of the business environment and future results. Moreover, they are useful for comparing similar firms operating in the same industry

but become meaningless when comparing firms in different industries. As an example, an ineffective firm operating in a high-growth industry (such as software) will have higher profit growth than effective apparel firms. At the same time, the risk analysis turns out to be cross-industry and related to the exposure of supply chains in different industries to different risk categories. The more global a chain is, the greater this exposure will be and the risk of slowdowns and problems will be higher.<sup>33</sup>

### *2.3.1 First cluster: diseases*

The first category of risk, namely that arising from the effects of pandemics, is a significant risk to the global supply chain. The above study focused precisely on analyzing the effects and damage mitigation strategies implemented by companies during this period. In general, understanding, management strategies, and supply chain optimization have become focal issues of corporate activity precisely because of the disastrous effects that the COVID-19 pandemic has had on the supply capacity of European and American companies heavily exposed to the Chinese market and beyond. Pandemics, and in this case the COVID-19 pandemic, are a real danger to people's health, and therefore links in the global supply chain must pay attention to managing and processing measures to prevent the transmission of this disease. The results of this study showed that risks from exogenous factors, such as in this case, can explain up to 12.6 percent of the variance in supplier performance, 25.2 percent in innovation and learning, 23 percent in internal business operations, 40.6 percent in customer service, and 32.4 percent in finance. These are remarkable percentages compared to previous studies<sup>34</sup> which found only 6 percent of the variance in supply chain performance explained by the proposed risks.

The study also points out that risks generated by natural factors (i.e., disease, natural disasters, and arson) can cause severe economic, political, social, and cultural fluctuations. In the case of the COVID-19 pandemic, nonpharmaceutical measures, such as social distancing policies and civic lockdowns, which were posed as tools to stop the spread of the virus, severely damaged supply chain performance. Policies implemented by governments around the world to stem the spread of the disease also affected export and import markets. In fact, travel bans, border controls, export restrictions and other restrictive measures were implemented during the pandemic period. Some of the negative repercussions of such policies

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<sup>33</sup> Thanh Pham H., Truong Quang H., Sampaio P., (2023). *The impact of global risks on supply chain performance. An empirical study on construction sector in the COVID-19 pandemic. International Journal of Quality & Reliability Management.* Pp. 6 – 8.

<sup>34</sup> Wagner, S.M. and Bode, C. (2008), *An empirical examination of supply chain performance along several dimensions of risk*, *Journal of Business Logistics*, Vol. 29 No. 1, pp. 307-325.

aimed at protecting public health were disruptions in supply-side transportation, severe labor shortages in domestic business activities, and innovation and learning activities, reducing the quality of customer service. All this has led to an imbalance between supply and demand for consumer goods globally, along with a sudden shift in end-customer needs for certain types of products and end-supply channels. In addition, it is highlighted in the study how the credit market has also been greatly affected, with depressive effects on commodity exchange rates. The study, however, points out that while the sudden spread of the virus and the severity of the measures have left very little room to identify ideal domestic alternative products in the short term, this contraction of both supply and demand could lead to less dependence on global value chains in the future due to issues of trust and transparency.

### *2.3.2. second cluster: war and terrorism*

The globalization of supply chains has led to increased interdependence among suppliers, manufacturers, distributors, and retailers. This interconnectedness, although beneficial for efficiency and cost reduction, makes these chains susceptible to widespread disruptions. In the event of an asymmetric attack on one of the nodes in the network, the damage could spread to the entire system, causing delays and operational disruptions with consequent effects on turnover levels and investor confidence. The geographic dispersion of supply chain components means that in the event of a terrorist attack in one location, the consequences could be far-reaching, affecting production schedules, inventory levels, and delivery times.

Yossi Sheffi, in his text "Supply Chain Management under the Threat of International Terrorism,"<sup>35</sup> explores the complexities and vulnerabilities of global supply chains in the face of asymmetric threats. Analyzing the phenomenon of terrorism, he highlights how such threats can severely disrupt these intricate networks, posing significant risks to the operational capability of companies. Moreover, he emphasizes how the effects could have major spillovers throughout the economic system, as seen in the 2001 Twin Towers attacks in New York.

The study provides an overview of the types of terrorist threats that can impact supply chains, emphasizing their hybrid and not always clearly identifiable nature. The first case study concerns physical attacks on critical infrastructure, which can cause serious systemic damage and have consequences for the economy of an entire regional area. For example, an attack on a major port could

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<sup>35</sup> Y. Sheffi. (2001). *Supply Chain Management under the Threat of International Terrorism*. Massachusetts Institute of Technology. Vol. 2, Nr. 2. Pp. 1-11.



block the flow of goods, creating bottlenecks and delaying shipments globally. These infrastructures are prime targets in armed conflicts, especially in the early stages of an attack. The NATO operation called Allied Force in 1999 is a clear example of the strategic nature of such infrastructure in the event of armed conflict.<sup>36</sup> The airstrike campaign, conducted for over two months against the Federal Republic of Yugoslavia, aimed to cripple the country by striking military and civilian targets, including bridges, power plants, and telecommunications facilities. Although this example did not have systemic consequences internationally, the key importance of these facilities on a tactical and strategic level is evident. Currently, continued attacks by Yemeni militias on container ships in the Bab-el Mandeb Strait are found to be a major threat to global shipping. This situation and its implications on the global value chain will be discussed in more detail later in this thesis paper.

Cyber-attacks pose another significant threat, targeting the IT systems that manage and control supply chain operations. These attacks can compromise sensitive data, disrupt communications, and halt automated processes, leading to significant operational challenges. The ongoing cyber-attacks on European and North American companies and government agencies by groups linked to countries such as Russia and China are a concrete example of the importance of digital infrastructure in the 21st-century economy. Recently, Italy also approved the draft legislative decree to implement NIS2 (EU) 2022/2555 (Network and Information Systems Directive), aimed at ensuring high levels of security of networks and information systems in the European Union. One of the earliest documented cases of a cyber-attack was allegedly the one conducted by Israel against Iran's Natanz nuclear power plant in 2010 via the Stuxnet computer worm, which destroyed 1,000 centrifuges used for uranium enrichment, almost permanently compromising Iran's nuclear program.<sup>37</sup>

In the area of supply chain-related cyber risks, one of the most notorious attacks is the SolarWinds Orion attack. In late 2020 and early 2021, as the world grappled with the COVID-19 pandemic and the U.S. with the transition of power after the presidential election, one of the largest cyber-attacks ever was perpetrated. Hackers inserted malicious code into the SolarWinds Orion Platform software update, reaching 18,000 companies and government agencies. The cybercriminals, from Russia, gained access

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<sup>37</sup> Weinberger, S. (2011). *Is this the start of cyberwarfare? Last year's Stuxnet virus attack represented a New kind of threat to critical infrastructure*. *Nature*, 474(7350), 142+.

to confidential data from numerous government agencies and private companies around the world, compromising the security of data and operations.<sup>38</sup>

In summary, the operational impacts of terrorist activities, both violent and cyber, on supply chains are profound and multifaceted. Such disruptions can lead to delays, increased costs, and damaged infrastructure, negatively affecting the efficiency and reliability of supply chains. Delays can disrupt production schedules, causing inventory shortages and lost sales. Increased security measures could result in additional operational costs, negatively impacting the company's bottom line. Infrastructure damage may require significant investment in repairs and reconstruction, diverting resources from other critical areas. In addition, the psychological impact of terrorism on employees and stakeholders can lead to a loss of morale and productivity.

### *2.3.3 Political and economic instability*

Political instability is a huge threat to the success of companies operating in the global supply chain. Organizations with global sourcing needs must understand the potential negative impact that political instability can have on productivity, quality, and relationships and create strategies to mitigate the risk. These threats must be carefully examined and mitigated by business operators through risk assessment and contingency planning.<sup>39</sup>

One of the most immediate and dangerous effects of political instability is the disruption of operations. Conflicts and civil unrest can lead to the blockage of key communication routes, damage crucial infrastructure, and hinder the movement of goods, causing significant delays in product deliveries. In response to political crises, governments may implement restrictive policies against other countries. Common measures include border closures and trade limitations. For instance, economic sanctions imposed by one country on another can restrict market access, prohibit the import of certain goods, and increase transaction costs. New regulations introduced in politically unstable contexts can impose severe

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<sup>38</sup> J. Martínez\*, Javier M. Durán. (2021). *Software Supply Chain Attacks, a Threat to Global Cybersecurity: SolarWinds' Case Study*. International Journal of Safety and Security Engineering Vol. 11, No. 5, pp. 537-545.

<sup>39</sup> O'Grady, P., & O'Hare, P. (2017). The impact of political instability on global supply chains. *Journal of Global Operations and Strategic Sourcing*. Pg- 1.

restrictions, such as high tariffs and complex compliance requirements, further complicating international trade and increasing import and export costs.<sup>40</sup>

A concrete example is the geopolitical situation triggered by the Russia-Ukraine conflict, which began in 2021 but has roots in 2014, causing severe disruptions in global supply chains. A study published in the *International Journal of Mechanical Engineering*, titled "Russia-Ukraine War and Risks to Global Supply," provides an overview of the causes and effects of global value chain disruptions related to this conflict. The study highlights three major causes: the disruption of key regional maritime routes, the suspension of maritime and land freight services, and the sharp increase in air freight rates.

More specifically, the study points out how the congestion of the Kerch Strait and the closure of the ports of Odessa and Mariupol are slowing down major maritime routes around the Sea of Azov. These blockages have halted 70% of Ukrainian exports by sea, with cascading effects on the regional economy and the supply of many European imports. Additionally, there have been missile attacks on commercial ships, with crew arrests and damage to tankers, container ships, and cargo ships from various countries such as Japan, Turkey, Moldova, and Estonia. Due to the high risk, many supply companies have suspended delivery services to and from Russia and Ukraine, leading to supply chain disruptions. The war has also exacerbated the shortage of seafaring personnel from Russia and Ukraine, who make up 14.5% of the global maritime workforce. Crew safety and rising insurance premiums have discouraged shipowners from accepting shipments to these two countries. Moreover, the disconnection of major Russian banks from the SWIFT system has complicated the payment of seafarers' salaries, further aggravating the situation.

Another cause of reduced cargo volume is air transport. Due to the closure of Ukrainian airspace and the reduction of civilian air traffic over Russia, there has been a sharp increase in air freight rates. Currently, manufacturing industries are facing severe risks due to the shortage of essential raw materials such as platinum, aluminum, sunflower oil, crude oil, and steel. This situation could further strain an already pressured supply chain, with cascading effects on the production capacity of European companies.

Neon gas and krypton are central raw materials for Ukrainian exports, essential for the production of electronic chips. Disruptions in the supply of these gases are creating serious difficulties for manufacturing companies, with shortages of components, delivery delays, and increased raw material

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<sup>40</sup> Manuj I., Mentzer JT., (2008). Global supply chain risk management strategies. *International journal of physical distribution & logistics management*.

costs. The effects of reduced availability of these products have a significant impact on industries such as the automotive sector, which heavily relies on chips. Companies in Japan and South Korea are attempting to access reserves, but the search for alternative suppliers outside Eastern Europe is causing further shortages and price increases.<sup>41</sup>

Political instability also has a significant impact on the financial risks associated with the supply chain. Political and economic crises can cause rapid devaluation of the local currency, negatively affecting import and export costs. This currency volatility can make it difficult for companies to plan and manage operating costs, introducing further financial uncertainty. Additionally, political turmoil can scare investors, limiting access to the capital needed to finance supply chain operations. This can compromise companies' ability to expand their activities, invest in new technologies, and maintain competitiveness in the global market.<sup>42</sup>

Another important effect of political instability is the deterioration of international trade relationships. Companies may lose trust in trading partners located in politically unstable countries, reducing cooperation, and increasing caution in transactions. This loss of trust can lead to reduced commercial activity and increased transaction costs as companies seek to protect themselves from potential risks. Furthermore, existing contracts may be unilaterally canceled or modified by governments in response to political changes, creating additional uncertainty for businesses. This contractual uncertainty can complicate the planning and execution of supply chain operations, increasing the risk of disruptions and delays.

#### *2.3.4 Fourth cluster: Social and Cultural Tensions*

Social and cultural tensions represent a significant challenge for the management of the global supply chain. These risks stem from ethnic, religious, class conflicts, or among different social groups, as well as cultural differences that can influence business operations and commercial relationships.<sup>43</sup> A striking example of such tensions is the Foxconn case, a Taiwanese company and one of the leading producers of

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<sup>41</sup> Nguyen Minh N., Dinh Thanh Dinh Thanh., Nguyen Hoang T., (2022). Russia-Ukraine war and risks to global supply chains. *International Journal of Mechanical Engineering*. Pp. 636-637.

<sup>42</sup> Sharma, R., Shishodia, A., Kamble, S., Gunasekaran, A., & Belhadi, A. (2020). Agriculture supply chain risks and COVID-19: mitigation strategies and implications for the practitioners. *International Journal of Logistics Research and Applications*, 1–27.

<sup>43</sup> Manuj, I., & Mentzer, J. T. (2008). *Global supply chain risk management strategies*. *International Journal of Physical Distribution & Logistics Management*.

electronic components for tech giants like Apple, Dell, and Sony, which was at the center of a series of tragic events in 2010.

During the boom period for iPhone product sales, in the assembly factories owned by Foxconn in Shenzhen, 18 workers, mostly young, attempted suicide within the plant, resulting in 14 deaths in 2010<sup>44</sup>. These events highlighted a work environment characterized by extremely high pressures, long working hours, low wages, and a rigid management style. Furthermore, the living conditions in company dormitories, marked by overcrowding and poor sanitary conditions, contributed to creating a highly alienating and oppressive work environment. The lack of psychological support and mental health services, along with minimal or absent safety measures, pushed the situation in these factories to the brink of desperation and stress.

Despite the high reputational risk, Apple managed to maintain stable revenue levels throughout 2010 by proactively investigating living and working conditions in its plants and implementing improvements to address or mitigate these issues. Actions taken by Foxconn, such as wage increases and the reduction of mandatory overtime, alongside measures adopted by Apple and other partners, marked an important turning point in human resources management in global supply chains. The lessons learned from this case sparked a broader debate on working conditions in electronics production factories, prompting many companies to reevaluate and improve their CSR practices and monitoring of working conditions.<sup>45</sup>

From the aforementioned example, the importance of managing and understanding the elements underlying social, cultural, and social revendication tensions emerges. The negative externalities resulting from social tensions can lead to significant disruptions in supply chain operations. Workers' protests, strikes, and other forms of civil disobedience can cause interruptions in production, distribution, and other critical activities, leading to delays and significant economic losses. Social conflicts, as observed in the Foxconn case, can cause severe infrastructural damage, delivery delays, and a general increase in security and operational costs, compromising the stability and efficiency of logistics operations.

Companies operating in contexts of social tensions can face compliance issues and reputational damage. Human rights violations are a primary concern; companies can be accused of human rights violations if they operate in countries with severe social tensions, putting their global reputation and consumer trust

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<sup>44</sup> Hua, J. (2024). *Dying for an iPhone: Apple, Foxconn, and the lives of China's workers*: by Jenny Chan, Mark Selden and Pun Ngai. *Asian Journal of Women's Studies*, 30(1), 51–54.

<sup>45</sup> Lioutas, E. D., & Charatsari, C. (2020). *Global trade and political risk: A business perspective*. *Global Business Review*.

at risk. A more recent case involves the fast fashion industry in China. The investigation "Untold: Inside the Shein Machine" by reporter Iman Amrani with Zandland Films, aired by All4 (British pay-TV of Channel4), showed the exploitative working conditions in a supplier factory of the fast fashion giant Shein. Although the company claimed to be unaware of the facts and condemned such practices, the damage to the industry's image remains undeniable.<sup>46</sup>

This underlines the importance of the already mentioned Corporate Social Responsibility (CSR) practices in mitigating the effects of social and cultural tensions in the global supply chain. CSR involves integrating social, environmental, and economic concerns into business operations and interactions with stakeholders. These practices not only help mitigate social and cultural tensions but also contribute to building a sustainable and responsible business model. By improving working conditions, engaging local communities, promoting diversity and inclusion, ensuring environmental responsibility, transparency, and training, companies can address the risks associated with global supply chain management and create long-term value for all stakeholders involved.<sup>47</sup>

In summary, international scandals like the 2010 Foxconn case and Shein, along with general social and cultural tensions, highlight the need for a more humane and responsible approach to managing global supply chains. Companies must be prepared to monitor and respond to social and cultural tensions, adopting strategies that ensure sustainability and operational efficiency while protecting the rights and well-being of workers.

## **2.4 Risks and threats to global supply chain in 2024**

The year 2023 has been marked by significant episodic upheavals, adding to an international situation already marked by the consequences of the COVID-19 pandemic and the ongoing war between Russia and Ukraine. Although this situation has exposed the deep cracks within our society, the global system has so far proved surprisingly resilient. Indeed, the recession widely predicted by leading international institutions has not materialized, and the financial turmoil created during the year has quickly abated, but the outlook nevertheless remains uncertain. Several regional conflicts and political struggles have captured the attention of international public opinion, while others have remained more muted but whose severity and extent of damage remains the same as significant. Currently, these developments have not

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<sup>46</sup> Mattioli G. (2022). *Shein, un'inchiesta shock rivela lo sfruttamento della manodopera*. La Repubblica.

<sup>47</sup> Trompenaars, F., & Hampden-Turner, C. (1997). *Riding the waves of culture: Understanding diversity in global business*. McGraw-Hill.

caused regional conflicts to widen, nor have they created globally destabilizing consequences such as those observed at the initial outbreak of the war in Ukraine or the COVID-19 pandemic. The long-term outlook, however, remains uncertain, with a focus on the clashes on the Israel-Gaza border and the Russian-Ukrainian conflict because of the potential risk of expanding hostilities on a broader regional scale. In addition to these critical issues there are new risk elements whose growing trends have emerged in recent years.

Given the importance for companies to understand their surrounding operating environment in order to implement all necessary actions to mitigate their exposure and make their supply chain more resilient, the Global Global Risks Perception Survey 2023-2024 (GRPS), prepared by the World Economic Forum, provides an overview of both current and prospective risk trends. This document is the World Economic Forum's main source of original global risk data and can be a valuable tool for systemic understanding of key global threats, thanks to the contribution of more than 1,490 experts from academia, business, government, the international community and civil society.<sup>48</sup>

#### *2.4.1 Global outlook and current risk landscape*

This study shows that a negative short-term global outlook characterized by instability is expected among respondents, with worsening expected over the next decade. As shown in the chart below, the majority of respondents (54 percent) expect some instability and moderate risk of global disasters, while another 30 percent expect even more turbulent conditions. On the long-term time horizon, the outlook becomes markedly more negative, with nearly two-thirds of respondents expecting a stormy or turbulent outlook.

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<sup>48</sup> World Economic Forum. (2023). The Global Risk Report 2024, 19th Edition. Pp. 4-37.

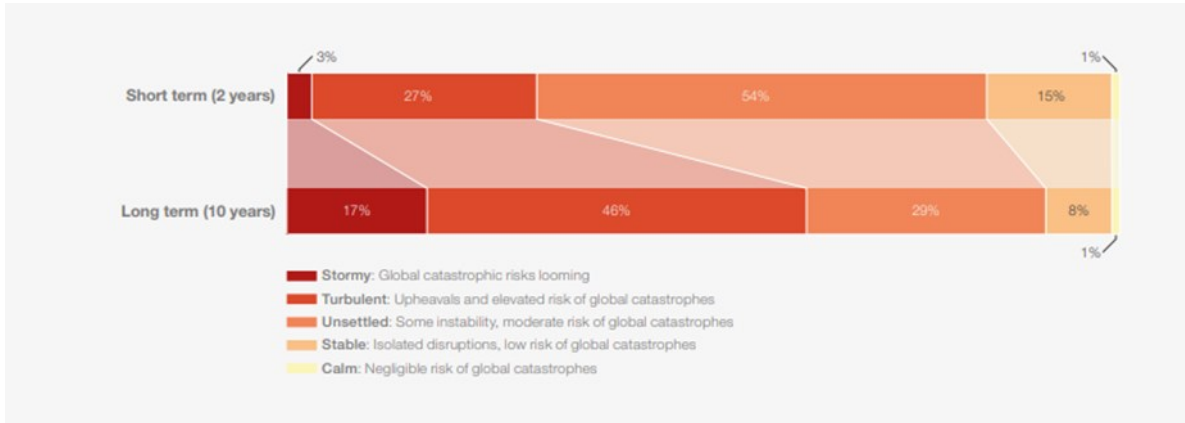


Image 3: Graphical representation of the survey results on the evolution of the Global Outlook in the short term (2 years) and long term (10 years). (Source: World Economic Forum. (2023). *The Global Risk Report 2024, 19th Edition*. Pg. 6)

This negative outlook is due to several different global risks that have a material impact on business performance and supply chains. Five risk clusters emerge from the interview that are most likely to represent a material crisis on a global scale in 2024, with a particular focus on the global value chain.

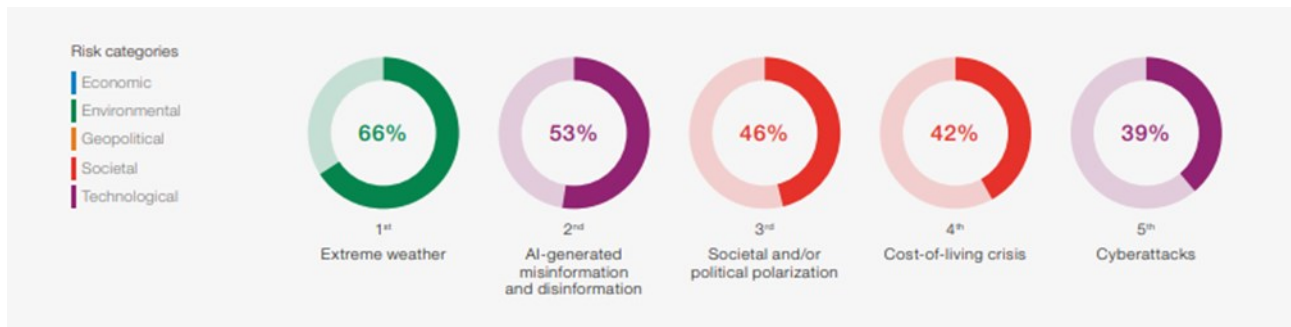


Image 4: Graphic representation of the current risk landscape (Source: : World Economic Forum. (2023). *The Global Risk Report 2024, 19th Edition*. Pg. 7)

The values shown in the middle of each graph represent the percentages of the sample that entered that typology of risk as one of the five that will be most likely to cause a material crisis during the year. The impact and severity with which these risks are likely to manifest are ranked in the graph below, and in which it is clear that over the course of the decade some events will increase their systemic impact.





Image 5: Global risks ranked by severity over the short and long term (Source: : World Economic Forum. (2023). *The Global Risk Report 2024, 19th Edition*. Pg. 8)

- Extreme weather

Climate change-related risks continue to be a major concern in both the short- and long-term. Two-thirds of GRPS respondents rank extreme weather as the most likely risk of a global-scale material crisis in 2024, with the warming phase of the El Niño-Southern Oscillation (ENSO) cycle<sup>49</sup>[1] expected to intensify and persist through May this year. However, there are differences on the perception of danger among different generations of respondents, particularly on biodiversity loss, ecosystem collapse, and critical change in Earth systems. In fact, younger respondents tend to rank these risks much higher in the short term than older age groups, with both risks still ranking in the top ten in the short term. Moreover, it emerges how the private sector places these critical issues as major concerns in the long term, in contrast to civil society or government respondents who prioritize them in the shorter term. This dissonance in the perception of urgency among key decision-makers results in suboptimal alignment and decision-making, increasing the likelihood of missing key intervention moments, leading to long-term changes in planetary systems.

- AI- generated misinformation and disinformation and societal and/or political polarization.

<sup>49</sup> El Niño-Southern Oscillation (also known by the acronym ENSO) is a periodic climatic phenomenon that causes strong warming of the surface waters of the Central-Southern and Eastern Pacific Ocean (Latin America) in December and January on average every five years, with a statistically variable period between three and seven years. The phenomenon causes floods in the areas directly affected, but also droughts in areas further away from it and other disturbances that vary with each occurrence. Developing countries that depend heavily on agriculture and fisheries, particularly those bordering the Pacific Ocean, are the most affected, although it is believed it can also have effects on a global scale through changes in atmospheric circulation across the planet.

This relatively new category of risk represents the most insidious and impactful of those that emerged from this study. The disruptive capabilities of manipulated information are rapidly accelerating as free access to increasingly sophisticated technologies proliferates, and at the same time trust in information and institutions are deteriorating. In the short term we will see an increasing number of actors benefiting from the soaring growth of the synthetic content industry, resulting in the escalation of social divisions, ideological violence and political repression. The increasing popularity of programs for producing "synthetic" content that do not require specific computer skills and are readily available on the market has led to the explosion of fake content such as photos, voice content, and counterfeit sites. This threat becomes even more insidious in a current context of partial deregulation of the generative AI sector, even as governments and international institutions are moving in this direction, as reflected in the new European AI Act legislation, i.e., the world's first regulation on artificial intelligence. Despite efforts to regulate an ever-growing and evolving field, it is unlikely that existing legislation on the subject knows how to keep up with the pace of development of such technologies. Misinformation using generative AI will cause both in the short term and in the long-term serious harm to society that will lead to an ever-increasing climate of instability and economic-social crisis due to the manipulation of individuals and the sharpening of social divisions and polarization of society. However, even as the insidious spread of disinformation threatens the cohesion of societies, there is a risk that some governments will act too slowly, facing a trade-off between preventing disinformation and protecting free speech, while repressive governments may use greater regulatory control to erode human rights.

2024 also represents the "election year" as nearly three billion people will go to the polls in several economies, including the United States, India, the United Kingdom, Mexico, and Indonesia. The presence of disinformation and false information in these electoral processes could seriously destabilize the real and perceived legitimacy of newly elected governments, with the risk of political unrest, violence and terrorism, and a long-term erosion of democratic processes. Some foreign and domestic actors could benefit from such polarization within different societies by fomenting such a situation through the dissemination of false or biased content. The identification of AI-generated misinformation and disinformation in these campaigns will not be clear-cut as the difference between AI-generated and human-generated content is becoming increasingly difficult to distinguish for both digitally savvy individuals and detection mechanisms. The ability of social media companies to ensure platform integrity will likely be overwhelmed in the face of multiple overlapping campaigns and the content on these platforms will be increasingly tailored to its recipients and targeted to specific groups, such as minority communities, as well as spread through more opaque messaging platforms such as WhatsApp, WeChat

or Telegram. Although regulators are trying to limit and identify such content, it is always at risk of being misaligned with the continuing evolution of synthetic content production tools. For example, an AI-generated election video could influence voters and fuel protests or, in more extreme scenarios, lead to violence or radicalization, even if the platform on which it is shared warns that it is made-up content. The implications of such a scenario could be nefarious for the very resilience of the democratic system and institutions. Indeed, if the legitimacy of the elections is challenged, there could be clashes, violence among different groups of the population, and in the most extreme cases, the collapse of the state. In a context where some of the world's most important democracies will go to the polls, including the U.S., this danger is amplified because of the importance system of the country. In addition, state-sponsored prevention and repression campaigns could deteriorate interstate relations, through the strengthening of sanctions regimes, cyber offensive operations with the associated risks of fallout, and the detention of individuals (including based on nationality, ethnicity, and religion).

- Rise in conflict

In the current geopolitical landscape, there are several geographic areas that are characterized by armed conflict and violence and whose risks to international economic stability are significant, due to the potential for tensions to widen to a larger regional scale and the energy and trade infrastructure in those areas being subject to threats and disruptions. Ongoing conflicts In Ukraine, Israel, and tensions in Taiwan are a major geo-political concern in 2024 according to the World Economic Forum survey.

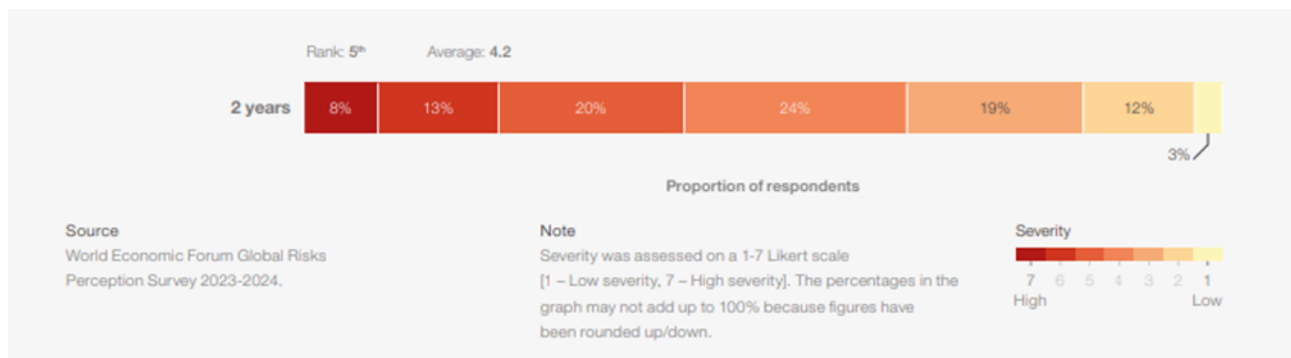


Image 6: Severity score: Interstate armed conflict (Source: World Economic Forum. (2023). *The Global Risk Report 2024, 19th Edition*. Pg. 22)

Based on this survey, the rise of armed conflicts is a major threat by 2024. In the next two years, specific outbreaks could absorb attention and divide the resources of major powers, degrading global security and destabilizing the global financial system and supply chains. Although a direct confrontation between two states remains highly unlikely, the continued deterioration of international security conditions will

exacerbate already precarious situations, worsening humanitarian crises and reducing the ability to respond to the needs of the civilian population.

The attention of major global powers will be focused particularly on the three geographical areas mentioned above, and in relation to global supply chains being, with different characteristics, play a central role in the global economy.

Regarding the conflict between Russia and Ukraine that began in February 2022, the impact on global supply chains has been discussed extensively in the previous paragraphs, but from a forward-looking perspective the conflict will be characterized by an alternation between an intensification and refreezing of hostilities. Moreover, despite sanctions Russia has continued to benefit from energy profits and commodity exports, which could increase further if the conflict in the Middle East escalates. All of this would go increase pressure on supply chains passing through that geographic area, further reducing the supply of raw materials from the East.

Israel remains a perennial hotspot because of its geopolitical location, historical conflicts, and the complex interplay of regional and international interests. The Israeli-Palestinian conflict continues to simmer, with periodic escalations involving regional and global actors. In addition, relations between Israel and Iran are fraught with tension, especially because of Iran's nuclear ambitions and its support for proxy groups hostile to Israel, such as Hezbollah in Lebanon and various militias in Syria. Since the October 7, 2023, bombing and the subsequent conflict inside the Gaza Strip, the situation in the area has further deteriorated, and recent developments in northern Lebanon portend a potential widening of the conflict. Should this materialize, the danger of direct involvement of other actors such as Iran would be highly likely, with repercussions for international stability and security.

The direct proximity of the Suez Canal and the Strait of Hormuz is a source of concern for global supply chain actors, as these are very conflict-sensitive bottlenecks that could quickly slow vital supplies in the event of paralysis. Since the end of 2023, many Israeli ports have been under maximum pressure due to difficulties in managing product flows by global supply chain actors. Since the beginning of hostilities, Israel's main ports, namely Ashdod and Ashkelon, are regularly on high alert, as they are highly exposed to the slightest attack by the Palestinian front. As a result, the business climate has deteriorated to such an extent that some shipowners, including ZIM Line, have begun to charge a "war tax" but have not ceased operations. In addition, shipping routes in the area have been further put under pressure due to continued attacks on commercial vessels by rebel militias of the Houti, an Iranian proxy in the Persian

Gulf. Due to the contingent situation in the area, several insurance companies are imposing a war premium on ships transiting this ultra-sensitive area of the Middle East, and it is very likely that shipowners will have to pass this on in their rates in the medium term.<sup>50</sup>

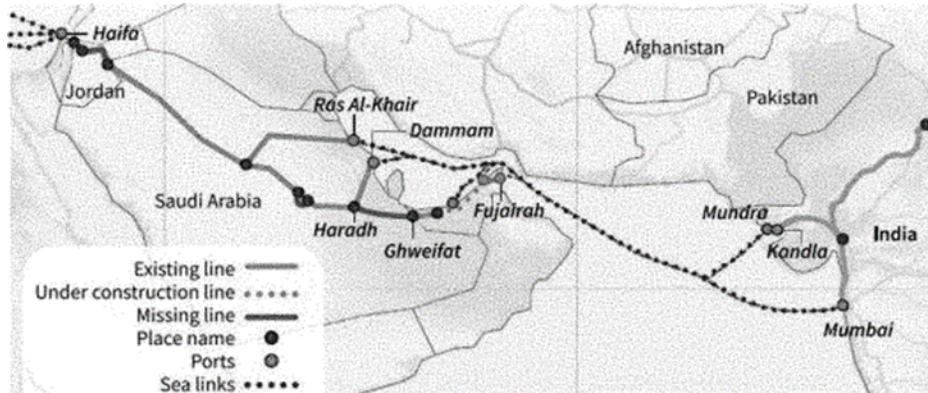


Image 8: The India-Middle East-Europe economic corridor (Source: *The Geopolitical Economist*. (2023))

Although it is easy for shipowners to alter routes to avoid sensitive areas of the world, it would be clumsy to ignore the adjustment cost this could represent. Given Israel's strategic importance in the India-Middle East-Europe economic corridor, continued conflict and lasting destabilization in the region will likely complicate the organization of many global supply chains, with impacts on final prices and companies' operating costs. As shown in the Global Container Index, an index that compiles the cost of major commercial shipping routes, the cost of this type of transportation has increased by about 80 percent since January 2024. This increase is caused by a combination of factors, including increased demand, congestion at ports in China and Singapore, and potential strikes. However, the serious threat posed by the Houthi rebels themselves and the insecurity of the Red Sea crossing they have caused is highlighted.

Several GRPS interviewees also cited Taiwan and disputed territories in East and Southeast Asia as areas of concern. Although at present there is no evidence to suggest that escalation is imminent, the real possibility of an accidental or intentional outbreak of hostilities remains, given the escalation of activity in the region. The island's central role in the Global Value Chain (GVC) is mainly due to its leading position in the production of semiconductors and advanced electronic components. Some of the global

<sup>50</sup> Pache, Gilles. (2024). *Israeli-Palestinian Conflict: Towards Major Logistical and Environmental Crisis?*. *Technium Social Sciences Journal*, 53, 252-258.

players in the production of such components, such as Taiwan Semiconductor Manufacturing Company (TSMC), provide crucial chips for a wide range of industries, from consumer electronic devices to automobiles and industrial equipment. Taiwan's importance is such that many global industries depend on its ability to produce essential technology components, without which global supply chains could suffer significant disruptions.<sup>51</sup>

Any conflict with China would pose a considerable threat to the GVC. Historically, since 1949 the People's Republic of China has regarded Taiwan as a rebellious province, and as such has advocated its reunification with Mainland China, including through the use of force. In the event of Chinese armed intervention, as threatened by current Chinese President Xi Jinping, there would be a dramatic disruption of semiconductor production and supply, causing ripple effects that would affect several industries globally. As demonstrated during the COVID-19 pandemic, the Global Value Chain is highly exposed to disruptions in this component

In addition, a conflict could lead to international sanctions against China, forcing companies to reorganize their supply chains, with the search for new solutions that are less efficient and more expensive in the short term. Geopolitical tensions between the U.S. and China add an additional layer of complexity. a further trade war between the two countries, with additional restrictions on the export of advanced technologies, could further exacerbate the situation the GVC's difficulties.<sup>52</sup>

- Cost of living crisis

Another real risk to the global supply chain is related to the cost of living, and in general to a possible slowdown in the global economy.

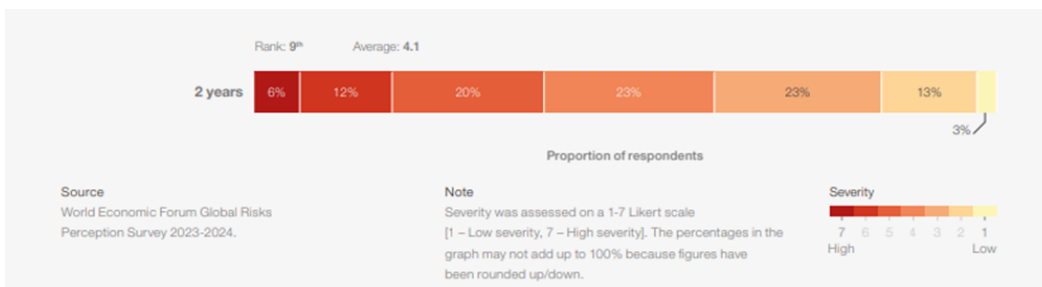


Image 9: Severity score: Economic downturn (Source: World Economic Forum. (2023). The Global Risk Report 2024, 19th Edition. Pg. 27)

<sup>51</sup> Business Insider. (2021). *How Taiwan's semiconductor industry has become crucial to the global economy and why China can't afford to take it over.*

<sup>52</sup> The Economist. (2021). *Why a Taiwan conflict could threaten global supply chains.*

As can be seen from the graph, more than 50 percent of the sample surveyed consider the severity of this risk to be at least moderately severe. As far as global supply chains are concerned, the rising cost of living can have a significant impact, manifesting itself through a range of economic and operational dynamics that affect the efficiency and sustainability of business operations. One of the main effects of this crisis can be seen in rising operating costs for companies. Rising inflation, combined with rising prices of raw materials, energy and labor, contributes to a general increase in production and distribution costs. This inflationary pressure affects both the costs of inputs needed to produce goods and higher transportation costs due to higher fuel prices. Together with these elements, the wage increases demanded by workers to compensate for inflation further contribute to higher operating expenses.

Parallel to this, there is also a reduction in consumer purchasing power. In fact, inflation erodes disposable income, leading consumers to reduce spending on nonessential goods, adversely affecting business sales and inventory and creating both a surplus of unsold products and at the same time a reduction in revenues. Businesses, therefore, face significant challenges in inventory management, balancing supply with variable demand, which could result in additional costs for storage and inventory management.

In addition, such a crisis could put pressure on corporate profit margins. To remain competitive in a market where consumers are more price-sensitive, firms may have to absorb some of the additional costs of rising raw material prices and operating costs, rather than passing them completely on to consumers. This trade-off, necessary to maintain competitiveness and preserve market share, has the effect of reducing profit margins, posing additional challenges to firms' financial sustainability. A well-articulated risk management strategy, along with effective resource optimization, are required to balance between managing costs and maintaining competitive prices.

#### *2.4.2 Global risks landscape: an interconnections map*

The various risks faced by global supply chains are not to be viewed as watertight compartments, but are highly interconnected, with some elements having greater systematicity than others. With a view to analyzing and classifying these threats, the study presents these categories separately, but at the same time offers a detailed analysis of the interconnectedness of potential threats.

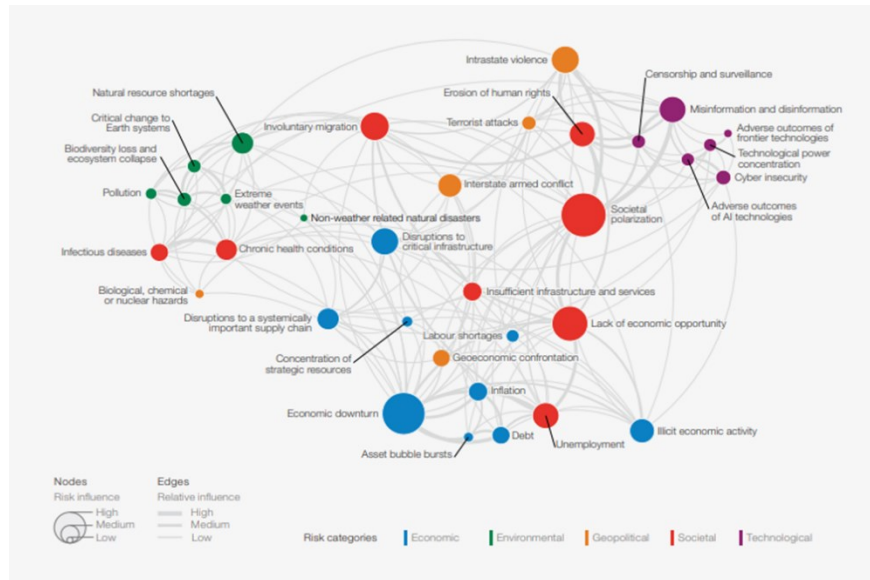


Image 10: Global risks landscape: an interconnections map (Source: World Economic Forum. (2023). The Global Risk Report 2024, 19th Edition, Pg. 10)

A comprehensive overview of what are all the potential risk categories and their connections to the other nodes in the diagram, i.e., the other risks, is presented from the diagram. It becomes clear from the study what the pivotal nodes and different risk clusters are.

## 2.5 Evolution and criticality of the supply chain from the COVID-19 pandemic to the present day

Interest among scholars and business managers in efficient supply chain management has accelerated dramatically following the economic and social consequences of the COVID-19 pandemic. Tensions in global production networks, also commonly known as supply bottlenecks, have emerged during this period, representing a multifaceted phenomenon. Policies implemented by various governments to mitigate the effects of the pandemic and to protect public health created major imbalances between supply and demand. Continuous openings and closures of different economies, significant monetary and fiscal stimulus, and high levels of accumulated savings (especially in advanced economies) have created very strong and unprecedented shifts in supply and demand. In addition, there has been a rotation of demand toward consumer goods given the severe constraints on consumption opportunities in the services sector (particularly travel, tourism and recreation), which has exacerbated the already strong cyclical recovery in the goods sector. Idiosyncratic supply chain disruptions (due to pandemic waves and



adverse weather events, for example) also played a crucial role, limiting both activity and trade growth and ultimately driving up prices.

To assess the effects and intensity of the occurrence of any of the risks examined in this thesis paper, the study of the consequences of the COVID-19 pandemic on the supply chain is an excellent benchmark. The ECB's Economic Bulletin (issue 8/2021)<sup>53</sup> provides an overview and analysis of the effects of supply chain disruption on the global economy by analyzing data from various European economic actors. This study examines the main features of current supply chain bottlenecks. First, it aims to disentangle supply chain disruptions from demand-side factors, arguing that while the latter are a manifestation of the current phase of the business cycle, the former may be holding back the pace of recovery and thus warrant close monitoring. Second, it provides an empirical assessment of the impact of supply chain disruptions on overall economic activity and prices, and assumptions about how they will evolve in the future.

### *2.5.1 Euro Area*

The study of the effects of the occurrence of exogenous risks on the supply chain is of interest in analyzing the impact of disruptions on the European manufacturing sector. Indeed, in 2021, economic recovery in the area was significantly affected by global supply chain disruptions. Real GDP growth was mainly sustained by the recovery of business services, while industry and construction contributed less due to shortages of imported inputs and equipment. These critical issues were driven by the interaction of several factors, which can be grouped into five main categories:

1. **Rebound in global demand for manufacturing goods:** After the initial contraction during the pandemic, demand for goods increased rapidly, exceeding the responsiveness of manufacturing.
2. **Semiconductor shortage:** The semiconductor crisis had a significant negative impact, particularly in the automotive industry.
3. **Logistical disruptions:** Logistical problems, such as congestion at ports and container shortages, have contributed to delivery delays.
4. **Blockade measures in Asia:** Strict blockade measures in key Asian countries disrupted the production of intermediate inputs.
5. **Time needed to increase capacity:** Time was needed to increase production capacity in semiconductors and ships.

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<sup>53</sup>ECB. (2021). *Economic Bulletin*. Pp. 51- 91.

The imbalance between the strong recovery in global demand and supply shortages has been more severe and prolonged than analysts initially anticipated. Given the restraining measures implemented by various governments globally, consumption opportunities in the services sector have shrunk sharply (particularly travel, tourism and recreation), generating a rotation of demand toward consumer goods and exacerbating a strong cyclical recovery in the goods sector. The global surge in household demand for high technology, together with supply disruptions resulting from the coronavirus pandemic (COVID-19), also generated a crisis in semiconductor supply, which has adversely affected the automotive industry with months-long lead times for delivery of vehicles sold in the European market. The spread of the Delta variant in some key semiconductor manufacturing countries located in the Asia-Pacific region (including Malaysia, Singapore, Thailand, and Vietnam) resulted in the reintroduction of stringent lockdown and containment measures in 2022. The result was limited capacity for both semiconductor foundry and cargo ships to transport goods to European and North American markets throughout 2022 and 2023.<sup>54</sup>

Extremely relevant to the European economy has been the shock suffered by container ships and in general the very sharp contraction in the availability, in the relevant markets, of goods transported via maritime routes. The collapse of world trade in April 2020 was the cause of the buildup of containers in Western ports, and as demand resumed after summer 2020, container shortages and vessel delays created significant bottlenecks.

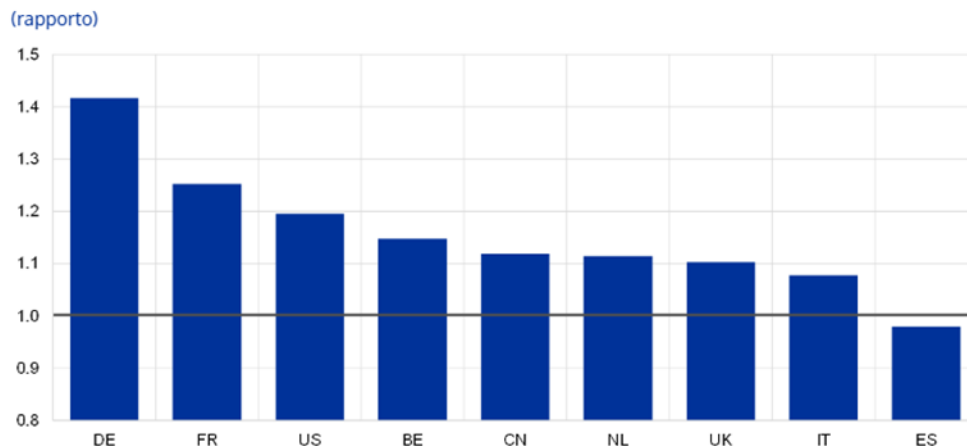


Image 11: Average port dwell time for container ships in the first half of 2021 compared to the 2018-19 average (Source: United Nations Conference on Trade and Development (UNCTAD) and ECB staff calculations).

<sup>54</sup> ECB. (2021). *The semiconductor shortage and its implication for euro area trade, production and prices*, Economic Bulletin, Issue 4.

Data emerging according to a UNCTAD study show that in the first half of 2021, the average time spent by ships in ports was 11 percent higher than the pre-pandemic average in 2018-19. German and French ports experienced very high increases in dwell times, by 42 percent and 25 percent, respectively. Belgium, Italy, and the Netherlands, on the other hand, showed changes more in line with the global average, still significantly higher than previous periods. Before the pandemic, an increase in demand usually led to an increase in production, causing a temporary lengthening of lead times and a reduction in inventories. However, since the second half of the 2020s, not only strong demand, but also supply bottlenecks have caused severe delays and decreased production, as well as shortages of materials and/or equipment that have prevented euro area firms from being able to adequately respond to the rapid recovery in demand for manufacturing goods, which subsequently led to declining inventories in all sectors.

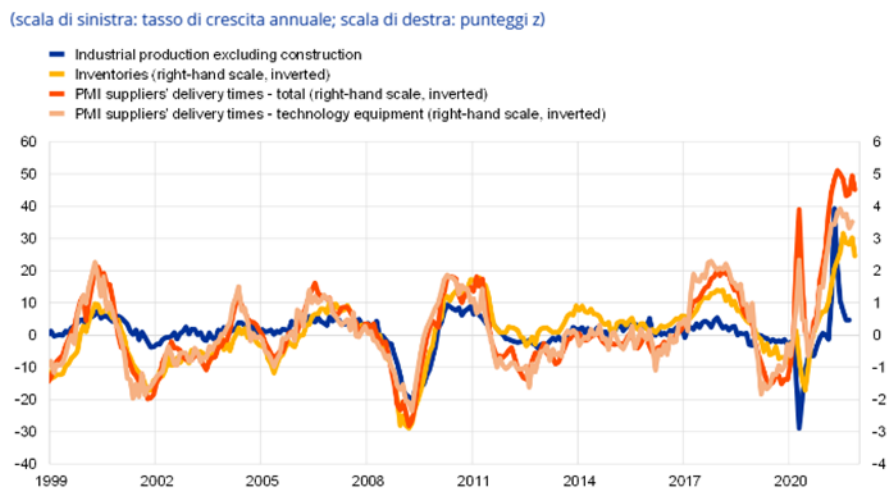


Image 13: The first graph shows euro area industrial production, supplier delivery times and stocks (Source: Eurostat, Commissione Europea, IHS Markit e calcoli del personale della BCE).

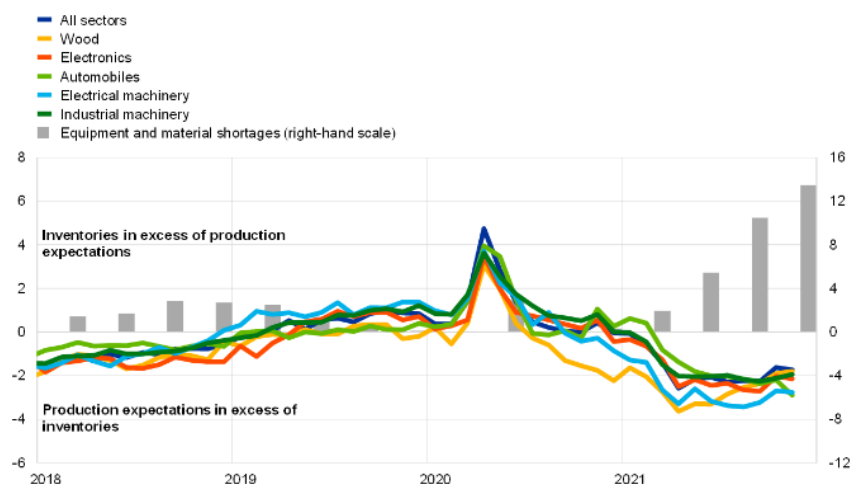


Image 14: The second graph represents euro area stocks against production expectations by sector and equipment and material shortages (Source: Eurostat, Commissione Europea, IHS Markit e calcoli del personale della BCE).

A vector autoregression model (SVAR) can be used to untangle the relative importance of the main drivers of developments in both lead time and industrial production. Specifically, this model identifies the contribution of demand, interest rates, financials, cost push shocks, and bottlenecks, using the HICP, industrial production (excluding construction), the 10-year OIS rate, firm spreads, and PMI supplier lead times. The model is based on aggregate euro area data from January 1999 to September 2021, and the shocks are identified using the method employed by J. Antolín-Díaz and JF Rubio-Ramírez in "Narrative Sign Restrictions for SVARs," *American Economic Review*.<sup>55</sup> This analysis suggests how supply bottlenecks significantly hampered industrial production in 2021. Indeed, it shows how between October 2020 and September 2021, about 45 percent of the variation in PMI supplier lead times was driven by aggregate demand, another 45 percent by supply bottlenecks, and about 10 percent by other cost-push shocks. Supply bottlenecks are estimated to have reduced the level of industrial production in the euro area by about 2.6 percent cumulatively over the period.

<sup>55</sup> The assumed sign restrictions at impact are as follows: demand shocks imply HICP (+); industrial production (+); ten-year OIS rate (+); corporate spreads (-); and PMI suppliers' delivery times (-). Interest rate shocks imply HICP (-); ten-year OIS rate (+); corporate spreads (+). Financial shocks imply industrial production (-) and corporate spreads (+). Cost-push shocks imply HICP (+) and industrial production (-). Bottleneck shocks imply HICP (+); industrial production (-) and PMI suppliers' delivery times (-). The assumed narrative restrictions are as follows: the largest contribution to the forecast errors for the ten-year OIS rate in January 2015 is attributed to monetary policy shocks; for corporate spreads in July 2007 it is attributed to financial shocks; for PMI suppliers' delivery times in April 2020 and March 2021 it is attributed to bottlenecks shocks. It is also assumed that all financial shocks have a positive sign in September and October 2008 and that all demand shocks have a negative sign in March and April 2020.

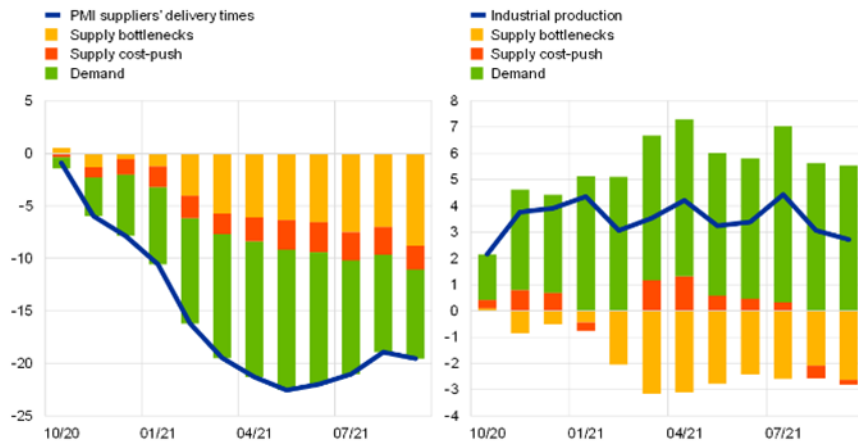


Image 15: Contribution of supply bottleneck shocks to euro area industrial production and PMI supplier lead times (Source: Eurostat, European Commission and ECB staff calculations).

The two regression models depict on the left side the diffusion index in deviation from baseline, and on the right side the percentage in deviation from baseline, cumulated from October 2020 to September 2021. The two graphs show how the effect of bottlenecks has become increasingly pronounced since February 2021. Based on the survey indicators available at the time of data collection and processing, it is suggested how the impact was not absorbed by the last quarter of 2021. Given that industry (excluding construction) accounts for about 20 percent of total euro area value added, SVAR estimates imply that real GDP growth in 2021 would have been about 0.5 percent higher in the absence of supply bottlenecks. This estimate can be considered a lower bound, as supply bottlenecks continued to affect output in the last quarter of 2021, as well as construction and business services. Sources of supply chain disruptions and their impact on euro area manufacturing

Since the second half of 2020, there has also been a steady increase in global shipping costs, reaching levels not seen since the Great Financial Crisis of 2008. In particular, transportation costs on routes from Asia and China to Europe, the Mediterranean and the United States have increased dramatically. Causing consumer confidence in global container service schedules to plummet This increase is mainly attributable to three factors:<sup>56</sup>

<sup>56</sup> ECB. (2021). *What is driving the recent surge in shipping costs*, Economic Bulletin. Issue 3.

1. **the first is increased demand for intermediate inputs:** The recovery in manufacturing activity has boosted demand for Chinese exports and container shipments.
2. **Shortage of containers at Asian ports:** This has exacerbated supply bottlenecks, with Asian companies paying increased fees to get containers back.
3. **Limited airfreight capacity:** Due to travel restrictions and cancellations that occurred during this historical period.

That study's predictions of the effects of supply bottleneck shocks correctly predicted performance results in 2022, characterized by a continuation of the critical issues that emerged in 2021. Indeed, semiconductor shortages, the pandemic in Asia, and congestion at ports are the factors that have continued to characterize the euro area throughout this period. This analysis highlights how supply bottlenecks have constrained industrial production and, consequently, economic growth in the euro area in 2021, with effects that have lingered to this day, even as a conduit for the current environment of political-economic uncertainty.

### *2.5.2 At a global level*

The factors that influenced disruptions in supply chains at the European level overlap to a very good extent with those that influenced trade and production at the global level. As can be seen from the data proposed by the ECB study, despite the commonality of significantly relevant elements in causing such a shock, there are some differences based on the geographical area of reference. Certainly, difficulties in the logistics sector, semiconductor shortages, and pandemic-related restrictions have played a central role in exacerbating the effects of bottlenecks on the global supply chain. The increase in shipping costs, which soared in 2020 in Europe and the U.S., was caused by the severe disruption of global goods shipping. Factors such as container displacement and congestion, the rotation of consumer demand from services to goods, associated high import volumes, and port closures due to localized and asynchronous outbreaks of COVID-19 have been central elements. Moreover, as already highlighted for the European case, the semiconductor crisis, was generated by a reduction in demand in the automotive sector and a simultaneous increase in demand for chips in the production of other electronic equipment. With the subsequent recovery in the second half of the 2020s in demand for vehicles, supply was unable to keep up because of little spare capacity remaining.

Regarding suppliers' longer lead times, it is a clear manifestation of the widespread tensions in global production networks. A commonly used indicator to monitor such tensions is the Global Purchasing Managers Index of Supplier Lead Times (PMI SDT). This indicator is a useful tool for quantifying changes in the time it takes to deliver inputs to companies. A major advantage lies in its ability to capture capacity constraints of different kinds, such as intermediate goods shortages, transportation delays or labor shortages, making it an all-encompassing indicator of tensions in global production networks.

By analyzing a time frame from 2012 to the second half of 2021, the actual trends in lead times in both advanced and developing economies can be understood. Despite the first and very strong shock at the beginning of 2020 due to COVID-19, starting from the end of that year and throughout 2021 the SDT PMI showed a significant lengthening of supplier lead times, outlasting the initial shock. Advanced economies, such as the U.S., the euro area and the U.K., were particularly exposed compared to major emerging economies. In addition, the rise in the SDT PMI is particularly pronounced in specific sectors, such as technology equipment and machinery, indicating a greater severity of intermediate goods shortages in these sectors.

A certain procyclicality with respect to output fluctuations is another element that has emerged from the increase in lead times. Indeed, the SDT PMI tends to move in close correlation with the overall manufacturing output PMI, which is a proxy for the business cycle. This suggests that as output increases, lead times tend to lengthen. To isolate movements in the SDT PMI from the normal elongation associated with cyclical fluctuations, a monthly bivariate vector autoregression (VAR) model was used for the global manufacturing output PMI (excluding the euro area) and the global SDT PMI. In this model, shocks from demand recovery and supply chain disruptions were identified using sign restrictions. Specifically, supply chain disruptions are assumed to lengthen delivery times and reduce output, while the increase in demand induced by economic recovery increases both delivery times and output. This approach allows the identification of structural shocks underlying movements in the SDT PMI, particularly supply-side shocks, which are used as a measure of supply chain shocks.

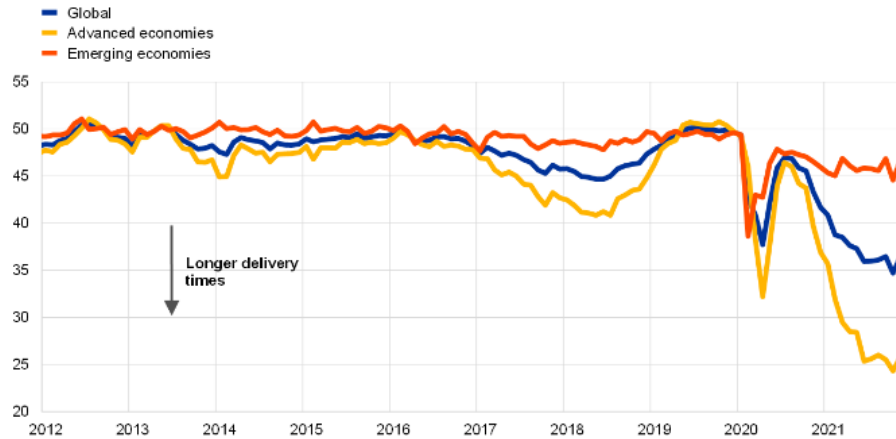


Image 18: PMI SDT across regions (Source: Markit and ECB calculation)

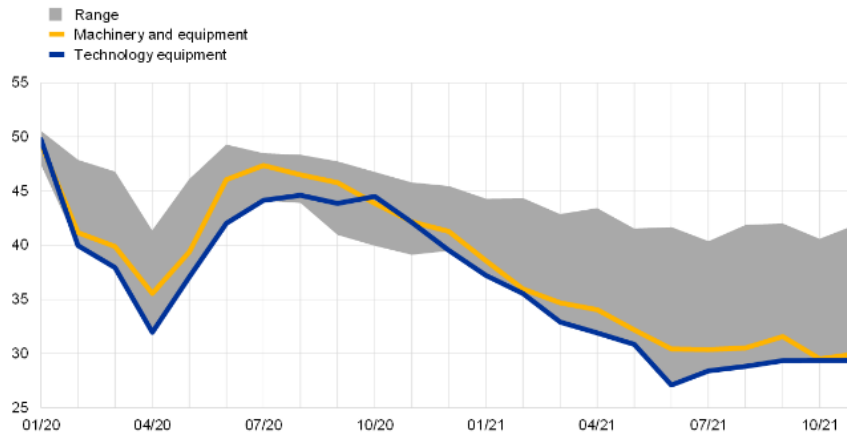


Image 19: Global PMI SDT across sectors. The shaded area in panel indicates the range between the minimum and the maximum PMI SDT level across 15 sectors (basic materials, chemicals, resources, forestry and paper products, metals and mining, consumer goods, automobiles and auto parts, beverages and food, beverages, food, house/personal use products, industrial goods, construction materials, machinery and equipment, technology equipment). (Source: Markit and ECB calculation)

Breaking down the time series, supply chain disruptions accounted for one-third of the extended lead time in 2021. Although demand factors played a primary role in determining the overall level of PMI SDT, the decomposition shows the centrality of the role of the supply chain especially in the first phase of the pandemic, being the main cause (and in some phases the only one), of the surge in delivery time. In contrast, in 2021 the role of this factor, while important, was minor compared to demand factors, which



is not surprising given the procyclicality of delivery times during periods of economic recovery (particularly after the exceptional historical recovery following the pandemic).

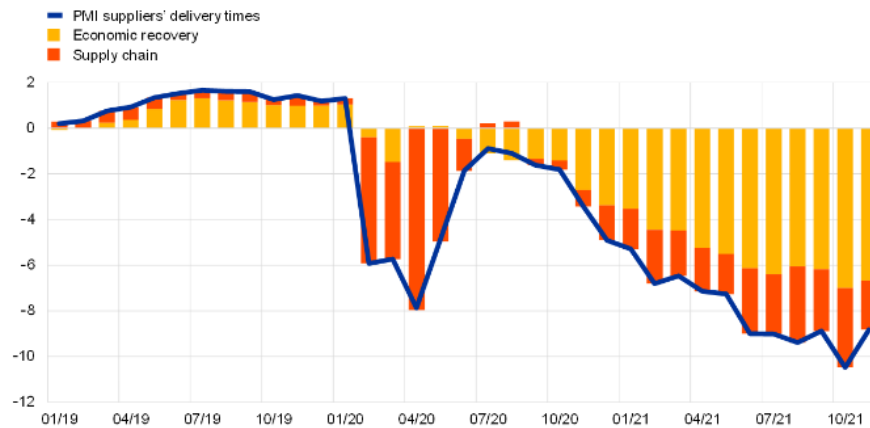


Image 20: A model decomposition of PMI suppliers' delivery times (ECB calculations based on Markit data.)

One element that seems to have played a minor role in the European market, but more prominent in the U.S. and U.K. markets, is labor shortages in the market. In both countries, labor market tightness indicators were already above pre-crisis levels, in contrast to the slow recovery after the global financial crisis. Items such as declines in matching efficiency and labor force participation partly reflect increases in unemployment benefits, early retirements and the need to care for children and other family members during the pandemic, as well as a reluctance to work in contact-intensive sectors.

The goal of this chapter of the thesis paper is to show empirically the effects of exogenous shocks on activity, trade and prices and, in turn, the counter effects it creates for economic recovery. For this reason, the analysis of the impact of the COVID-19 pandemic and its consequences on the international economic system is an excellent benchmark for fully understanding its magnitude. By analyzing data from the economic actors involved in the study, it is possible to affirm how supply chain disruptions generate a negative impact on global industrial production and trade, while at the same time having a positive impact on inflation. To state this, an accompanying VAR was constructed in which the estimated supply chain shock is entered into the model as an exogenous variable, while the endogenous variables are represented by:

- Exports
- Imports

- Industrial production
- Inflation rates for the consumer price index
- Producer price index

For it to be possible to quantify the impact of the exogenous shock on activity, trade and prices, a counterfactual scenario was used, constructing a scenario in which the value of the shock is set to zero for the entire reference period, i.e., that with no supply chain disruptions.

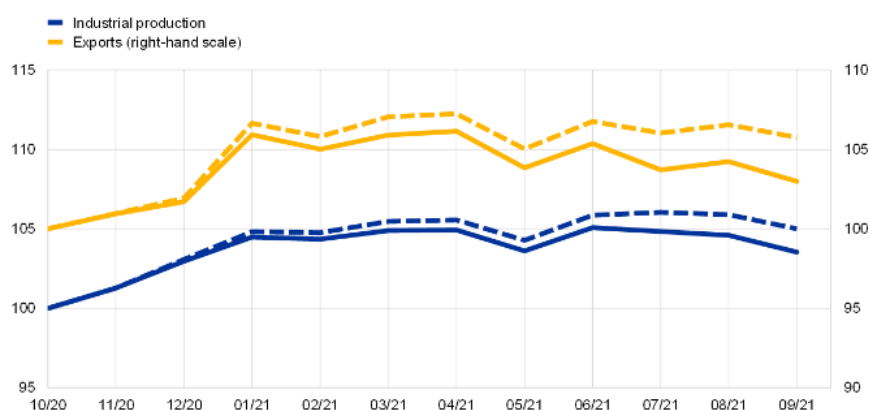


Image 21: World (excluding euro area) trade and industrial production (Source: ECB calculations based on Markit, CPB and OECD data)

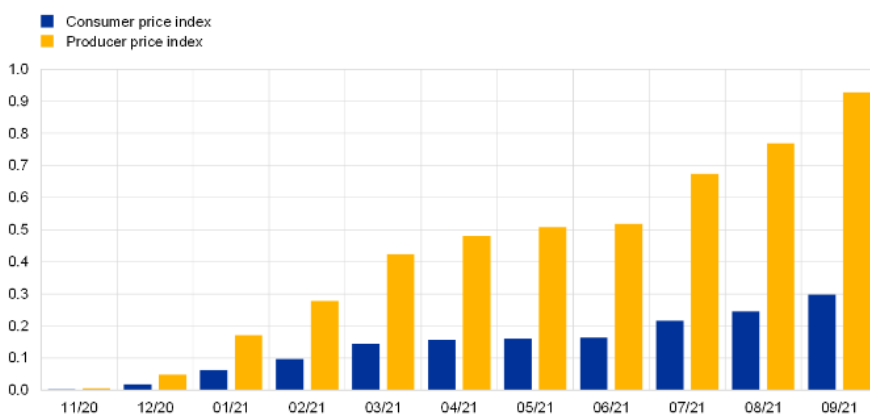


Image 22: World (excluding euro area) consumer price index and producer price index (production (Source: ECB calculations based on Markit, CPB and OECD data)

For the period under consideration, it is estimated that world trade would have been cumulatively about 2.7 percent higher in the absence of supply chain shocks, while global industrial production would have

been about 1.4 percent higher, as shown in the graph in Image 21. The effects appear to be more pronounced on trade than industrial production due to the weakness of the logistics sector, which has disproportionately affected international trade. In addition, the tendency to turn to domestic suppliers and goods may have mitigated the negative impact on industrial production. Moreover, our results indicate how disruptions in supply chains had a significant and increasing effect on prices over time, an effect that is much more evident in the producer price index than in the consumer price index (image 22). This phenomenon can be attributed to the fact that producers are directly exposed to disruptions in supply chains, while consumers are affected only partially and/or with a time lag. In addition, the increase in producer prices is only partially passed on to consumers. Importantly, the aggregate results hide significant heterogeneity across countries, as the exposure and impact of bottlenecks turns out to be not to the same extent for all. As an example, in the U.S., the effects are particularly pronounced, with trade and industrial production at 4.3 percent and 2.0 percent, respectively, below the counterfactual scenario without bottlenecks.

In conclusion, the empirical analysis of the effects of exogenous shocks, such as those resulting from the COVID-19 pandemic, on economic activity, trade and prices showed the significant and complex impact of disruptions in supply chains globally, with differences by country and geographic area analyzed. The increase in supplier lead times, detected through the SDT PMI, was a clear manifestation of tensions in global production networks, disproportionately affecting trade relative to industrial production due to the fragility of the logistics sector. In addition, the analysis showed how these shocks had a marked effect on producer prices, reflecting the difficulties faced by producers in adjusting to new market conditions. Despite some regional and sectoral differences, the results underscore the need for targeted policies to improve the resilience of supply chains and to mitigate the negative effects of future disruptions on global economic stability. The next chapter will address precisely the analysis and understanding of supply chain risk management (SCRM) strategies and the application of new technologies in increasing firms' predictive, operational and adaptive capabilities.

## CHAPTER THREE

### Mapping Supply Chains and Analysis of Risk Management Tools (SCRM)

The impact of the COVID-19 pandemic on global supply chains has been unprecedented. The previous chapter analyzed the impact on the European and global economy of disruptions and bottlenecks in business supply chains, highlighting the weaknesses and criticalities of these structures at the onset of the pandemic. This situation has led many scholars and business managers to study which tools can make the supply chain more resilient to these exogenous shocks. For this reason, Supply Chain Risk Management (SCRM) has become a critical component of business management, particularly in an increasingly globalized and interconnected economic and political context.

Mapping the supply chain by companies thus becomes a fundamental tool for understanding the risks and potential of their structure and the operating environment of suppliers. Companies often lack full awareness of their supply structure due to their global presence consisting of suppliers, sub-suppliers, and multiple connections between different entities.

To understand the risks companies are exposed to, it is essential first to know their current flow structure through an AS-IS mapping of business processes, highlighting all the actors involved and the associated timelines. Only once the operational context and process structure are understood, will it be possible, through the tools provided by the literature and corporate experience of SCRM, to identify these exogenous risks, locate them, and assess their systemic impact on the entire supply flow.

By understanding the operational context and their supply structure, companies can structure risk mitigation solutions and streamline the entire structure based on identified pain points and emerging criticalities

#### 3.1 Mapping - Why and Why Now

Supply chain mapping is the first step towards effective strategic supply chain management. It is an effective tool for linking "business strategy to supply chain strategy" to identify both performance improvement and network redesign opportunities, as well as potential risks and criticalities to which it is

exposed.<sup>57</sup> It enables managers to have the necessary level of understanding of their supply chain configuration to better address its impact on supply chain planning, management, and control. At a detailed tactical/operational level, value stream mapping is used to identify and remove non-value-adding activities in supply chains.<sup>58</sup> It is also essential for developing an initial understanding of the supply chain for the proper use of strategic performance tools, including the SCOR model and key supply chain performance indicators.

### *3.1.1 Emerging Trends*

Emerging trends in supply chain mapping are gaining increasing relevance in response to various economic, technological, and social dynamics that have occurred in recent years. Firstly, the inherent risks of dispersed global supply chains have become evident, accentuating concerns about disruptions, shortages, and reputational risks related to ethical, social, and environmental practices. As highlighted in the previous chapter, the consequences of exogenous events have made supply chain risk management a key area of interest for both researchers and industry professionals, with increasing emphasis on cybersecurity. Companies are developing supply chain maps to enhance visibility and mitigate such risks by creating digital twins and central control towers that monitor real-time operations.

Simultaneously, technological advancement and digitalization are transforming supply chain operations. The implementation of smart factories, Industry 4.0 initiatives, and advanced logistics systems, along with the migration to cloud-based infrastructures, is redefining how data and resources are managed. These new technologies promise to further revolutionize the configuration, management, and control of supply chains, enabling dynamic real-time modeling, pervasive connectivity, and immutable digital traceability.

As previously highlighted in the risk overview, sustainability has become a dominant concern. Increasing awareness of environmental and social issues has led to more stringent regulatory requirements for companies, while consumers, particularly Millennials and Generation Z, show growing interest in the origin and authenticity of products. This has pushed companies to provide more transparent guarantees about the authenticity of their products, especially in the luxury goods and food sectors.

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<sup>57</sup> Hines, P., Rich, N. (1997). *The seven value stream mapping tools*. Int. J. Oper. Prod. Manag. 17, 46–64.

<sup>58</sup> Gardner, J.T., Cooper, M.C. (2003). *Strategic supply chain mapping approaches*. J. Bus. Logist. 24, 37–64.

Furthermore, a central theme of this thesis is the impact of regulations and geopolitics on the configuration of supply chains. Sectors such as pharmaceuticals and food have always been subject to strict regulatory regimes, but new legislation concerning conflict zones and modern slavery is expanding the scope of such controls. Security and resilience of supplies have become strategic priorities in the post-pandemic era, with a particular focus by the European Union on analyzing global value chains for critical raw materials. In this context, detailed and accurate information-based maps are essential for facilitating risk analysis, surveillance, and early identification of supply issues, helping to ensure the continuity and sustainability of global supply chain operations.<sup>59</sup>

### 3.2 Evolution of the Concept of Supply Chain Mapping

Supply chain mapping is defined as a diagrammatic representation that provides a "resemblance and simplified model" of the supply chain, visualizing and providing information about its key characteristics. It is essential that such maps present accurate and understandable information to facilitate visibility, analysis, and integration of the chain itself. In early studies on the subject, the supply chain map was considered a "counterpart of the real environment," recognizing, however, that the perception of the map varies depending on the individual. This diversity in perception represents a challenge for the use of maps as a standard reference and as a tool for supply chain integration. Subsequent studies have indeed contrasted different mapping perspectives, such as the "network picture" and the "boundary object," with the positivist approach. A supply chain map, understood as a boundary object, can be interpreted and used as a communication tool across different business and functional boundaries. In the study by Mubarik et al. (2021)<sup>60</sup>, a construct was developed to measure the level of supply chain mapping based on information about suppliers, customers, materials, processes, and technologies, as well as the level of digitalization and availability of real-time data. However, the degree of mapping depends on the specific purpose, making it challenging to develop a universal metric based on standard KPIs.

The distinction between supply chain and value stream, introduced by Hines and Rich in 1997<sup>61</sup>, highlights the differences between all the activities of the involved companies and a sequence of activities that add value. Specific tools for value stream mapping vary depending on the desired objectives. In

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<sup>59</sup> Bart L. MacCarthy, Wafaa A.H. Ahmed, Guven Demirel. (2022). *Mapping the supply chain: Why, what and how?* International Journal of Production Economics. Pp. 4-5.

<sup>60</sup> Mubarik, M.S., Kusi-Sarpong, S., Govindan, K., Khan, S.A., Oyedijo, A. (2021). *Supply chain mapping: a proposed construct*. Int. J. Prod. Res. 1–17.

<sup>61</sup> Hines, P., Rich, N. (1997). *The seven value stream mapping tools*. Int. J. Oper. Prod. Manag. 17.

2003, thanks to the study carried out by Gardner and Cooper<sup>62</sup>, the differentiation between business process mapping and supply chain mapping in terms of orientation (internal vs. external), purpose (tactical vs. strategic), and level of detail was further refined. Although value stream mapping is often extended to buyer-supplier dyads and beyond, the contrast based on purpose (tactical/operational vs. strategic) prevails, as supply chain maps are primarily used to develop and communicate strategy among stakeholders.

At a strategic level, there has been an increasing interest in mapping global value chains at an aggregate level between countries and industries, raising policy questions related to supply chains. In 2005, Taylor formalized value chain analysis as a multi-stage process, starting with the identification of business purpose and developing an overall map of the supply chain structure. While this framework usefully links strategic and tactical/operational level maps, many studies remain purely strategic, not considering the breakdown of the mapping process at a more operational level.

### **3.3 Analysis of the Structure and Level of Inquiry in Supply Chain Mapping**

The AS-IS mapping of the supply chain is a crucial activity for analyzing and understanding the current state of the supply chain. This preliminary phase is essential for identifying operational criticalities, inefficiencies, and exogenous risks, in order to develop targeted improvement strategies. A supply chain includes all the processes involved in the production and delivery of a product. Since the early definitions of what a supply chain is, it has been defined as "a system whose constituent parts include material suppliers, production facilities, distribution services, and customers connected through the flow of materials and the return flow of information."<sup>63</sup> However, it must be considered that supply chains are composed of geographically dispersed and distinct economic entities. Generally, no single part owns the supply chain, even though dominant actors are present. For this reason, it is important.

Supply chain mapping is a critical activity for understanding and optimizing the flows of materials, information, and money throughout the supply chain. It allows for the identification of inefficiencies, bottlenecks, and risks, as well as the development of continuous improvement strategies. Before proceeding with the analysis of mapping methods, it is important to define the basic elements of mapping,

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<sup>62</sup> Gardner, J.T., Cooper, M.C. (2003). *Strategic supply chain mapping approaches*. J. Bus. Logist. 24.

<sup>63</sup> Md Didarul Islam. (2023). *A survey on the use of blockchains to achieve supply chain security*. Information Systems. Pg.2.

also in relation to the scale of analysis used. Supply chain maps can have different utilities and purposes for the actors involved.

### 3.3.1 Supply Chain as a Set of Processes

The basic definition of a supply chain suggests it is a system composed of material suppliers, production facilities, distribution services, and customers, all connected through flows of materials and information. Therefore, the supply chain includes all the processes involved in the production and delivery of a product. Essentially, it is a set of processes, a series of interconnected and coordinated activities that transform inputs into outputs, with the aim of creating value for the final customer. These processes include all the operations necessary to manage the flows of materials, information, and money along the supply chain, from raw material suppliers to the delivery of the finished product to the customer. Each process within the supply chain contributes to the overall functioning, ensuring that products are available at the right place, at the right time, and in the right condition. Supply chains are composed of geographically dispersed and distinct economic entities, with no single part owning the entire chain, although dominant actors may exist.

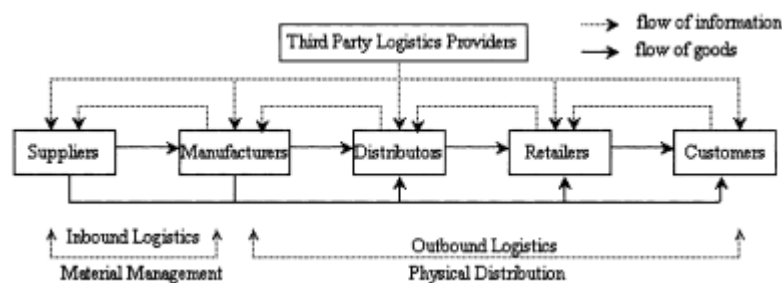


Image 23: Example of schematic representation of the supply chain process (Source: H.Min, G. Zhou. (2002). Supply chain modeling: past, present, future. Computers & Industrial Engineering, volume 43, numbers 1-2. Pg. 232).

Modeling such business processes allows companies to better understand their operations and facilitate communication within the organization. A business process model provides a solid foundation for creating appropriate information systems, as activity descriptions help identify the necessary systems to support them. Furthermore, such models are fundamental for requirements engineering during the design of a specific information system. Another key objective of business process modeling is to improve the



current structure and functioning of the company. By offering a clear view of the current state, the model can be used to identify and implement necessary changes to improve business operations. Business process models also serve as platforms for experimentation, as they can be used to test new business concepts and study the implications of changes in the structure or functioning of the business. Finally, these models are useful for identifying outsourcing opportunities. By analyzing the model, it is possible to distinguish the core parts of a business system from less critical activities that can be delegated to external suppliers. All this highlights the fundamental importance of modeling a company's supply chain processes, not only to identify criticalities but also to restructure these processes to make them more resilient to the potential risks identified during this analysis phase.<sup>64</sup>

### 3.3.2 Structural and Informational Elements of Supply Chain Mapping

To construct a supply chain map, it is first necessary to define and identify the minimum informational requirements, adopting a network science perspective that models a system as a set of nodes (supply chain participants) and links (connections between participants).

- **Nodes:** These can be divided into primary and secondary participants. Primary participants are entities that directly contribute to value-creating activities, while secondary participants include third-party logistics providers, customs agencies, auditors, regulatory authorities, financing, and insurance companies.
- **Links:** Value accumulates as a product passes through value-adding stages. Material, informational, and financial flows must be considered, along with their direction. Other types of links, such as competition, contractual relationships, cooperation, and technology transfer, may also be relevant.

These two elements represent the minimum information needed to construct an effective supply chain map, but additional complementary information is necessary to have a comprehensive overview of these processes in relation to both the context and the purpose of the analysis.

- **Physical Assets:** This includes production machinery, storage, and transport facilities.

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<sup>64</sup> H.Min, G. Zhou. (2002). *Supply chain modeling: past, present, future*. Computers & Industrial Engineering, volume 43, numbers 1-2. Pg. 230-242.

- **Spatial Data:** The geographical location of key actors and their facilities, such as warehouses, production plants, distribution centers, and ports.
- **Operational Data:** Information on production plans, performance, production capacities, goals, tools, and resources, including transportation modes and technologies such as information systems.
- **Intellectual Property:** Intellectual property rights and quality certifications.
- **ESG Issues:** Environmental, sustainability, and governance (ESG) information, including CO2 emissions, recycling processes, and labor contracts addressing modern slavery.

The unit of analysis, or the boundaries of the mapped supply system, depends on the nature, objective, and scope of the study. It can range from a short segment of a linear chain to a vast network encompassing multiple supply lines. Companies deep within the network can be crucial for supply chain performance. Some mapping studies may extend beyond immediate suppliers and customers, depending on the purpose. Additionally, the level of detail or granularity of the information depends on the unit of analysis and the purpose of the mapping. Specific information on the operations of participating organizations, quality, environmental, and sustainability issues may be of particular interest to stakeholders. The growing focus on sustainability requires the traceability of previously overlooked data, such as CO2 emissions, recycling processes, and labor contracts.<sup>65</sup>

### 3.3.3 Scale of the Supply Chain

Despite different levels of detail and units of analysis for developing supply chain maps, there is still confusion in the terminology of "supply chain mapping" for different levels of aggregation. Pre-COVID literature mainly contrasted strategic supply chain mapping with tactical/operational process mapping but remained largely silent on the subcategories of strategic supply chain maps. Therefore, before analyzing supply chain mapping methods, it is necessary to define a structured classification of maps using a hierarchical perspective of supply systems.

The first level is represented by Global Value Chain (GVC) mapping, which provides a holistic macro-level representation of global production networks and trade flows for goods and industries. The scale of analysis is usually at the country or industry level, as such mappings focus on the concept of trade in

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<sup>65</sup> Bart L. MacCarthy, Wafaa A.H. Ahmed, G.Demirel. (2022). *Mapping the supply chain: why, what and how?* International Journal of Production Economics. Pg. 5.

value-added, allowing the identification of the position of countries and regions in the value chain. As seen in the analysis of bottleneck impacts during COVID-19, this level of analysis supports both policy and macroeconomic issues and provides a broader context for supply systems mapped at finer levels of granularity. For this second reason, understanding the state of supply chains at a broader level enables companies to structure their supply chain to withstand potential systemic shocks by analyzing reference areas at a macro level and considering exogenous risks as analyzed so far.

At a lower level, products and services are created through multi-tiered complex supply networks between distinct companies. Supply networks are theorized as complex systems with emergent, self-organizing, and adaptive capabilities, where companies do not have global control, unlike short and serial supply chains where one or more dominant actors exist. Supply networks include all value-adding and non-value-adding activities and stakeholders involved in the development, production, delivery, and distribution of products and services, from conception to consumption. They may focus on the industry or the company, but in both cases, they explicitly capture entities at the company level. Supply network maps primarily focus on studying the overall network topology (who is connected to whom) for strategic purposes. Although often used interchangeably, the concept of a supply network differs from that of a supply chain (the lower level of the scale of analysis) by the presence and identification of dominant actors in supply chains. Moreover, supply networks are more than the sum of the supply chains

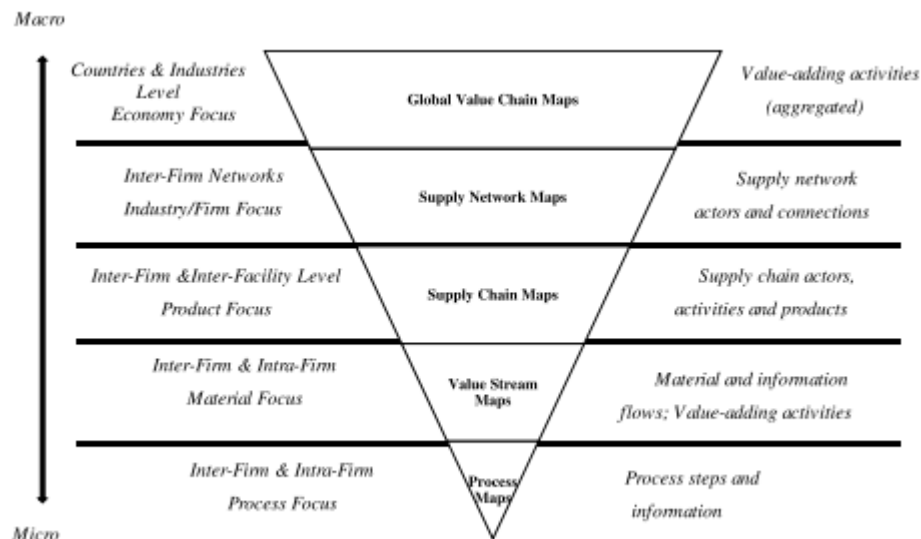


Image 23: Graphical representation of the hierarchy of supply chain mappings. From the top are the macro-level mappings, starting with the GVC mapping, down to the more granular mappings such as VSM and process mappings. (Source: Bart L. MacCarthy, Wafaa A.H. Ahmed, G.Demirel. (2022). Mapping the supply chain: why, what and how?. International Journal of Production Economics. Pg. 5)

### 3.4 Phases of AS-IS Mapping

Once the scale of the mapping analysis and its constituent elements are defined, data collection can begin, and the desired mapping can be drawn using various visualization tools. In this specific case, the scope will be at a strategic level to visualize the criticalities and the exposure of the supply network to geographically dispersed exogenous events.

#### *3.4.1 Data Collection, Processing, and Understanding for Mapping Physical and Informational Flows*

Data collection is the first fundamental step in supply chain mapping. The information to be presented in a supply chain map varies depending on the purpose, scope of the mapping exercise, and the mapper's perspective. Identifying data sources in an increasingly interconnected and global business context is not always easy, even for management. The use of consulting firms for mapping these processes has significantly increased following the COVID-19 pandemic, with many companies implementing processes to streamline and optimize their supply chains.

The classification of data sources is the first step toward understanding them. There are two main categories of sources, distinguished by the method of data collection:

##### 1. Primary Sources

This category is based on data collection using interviews, direct observations, company documents, and enterprise information systems (typically ERP systems). This methodology allows for an in-depth understanding of different processes and provides valuable details, but it is laborious and time-consuming, increasing costs for the company, especially if the analysis is delegated to external providers like consulting firms. Moreover, suppliers tend not to disclose their business data to avoid them becoming public and a potential advantage for competitors. This methodology is primarily used for value streams and short chains.

- Interviews and Questions: These are the primary methods for collecting qualitative data. They gather detailed information from internal and external stakeholders, including suppliers and customers. Interviews provide valuable insights into stakeholders' perceptions, experiences, and expectations regarding the supply chain, while questions collect standardized data on a wide range of topics.

- Direct Observations: This method monitors operations in the field and collects real-time data. It helps understand operational processes, identify inefficiencies, and assess working conditions. The use of sensors and IoT (Internet of Things) devices is an advanced solution for real-time data collection on the supply chain, monitoring parameters such as temperature, humidity, location, and condition of goods.
- Tracking Systems: Technologies like RFID (Radio Frequency Identification) and GPS (Global Positioning System) monitor the movement of goods along the supply chain, providing real-time visibility of logistics operations, improving efficiency, reducing delivery times, and ensuring the security of goods.

## 2. Secondary Sources

Secondary sources include market data (reports, industry analyses, benchmarking studies, and data from external analysts) and public and Open Data (government statistics, industry reports, and research studies). Institutional and non-institutional sources provide aggregated data on various industries and sectors. For example, UN ComTrade and Eurostat provide monthly international trade data for products grouped at different sectoral levels. At the European level, Eurostat aggregates these data regionally, while FAOSTAT groups them sectorally (agri-food). Secondary data can enrich and provide context for the primary data collected.

- Input-Output Tables: International trade databases do not capture connections between different products, such as which products serve as inputs for other products. This is crucial for constructing global value chains and understanding where value is created. Economic input-output tables capture financial flows between different industries within a country or a reference area. These tables can be extended to a multinational context, capturing exports and imports between various industries at corresponding stages of a global value chain. Examples include tables provided by the OECD and the World Input-Output Database (WIOD). Despite their utility, the use of input-output tables in supply chain management literature has been limited and mostly descriptive until recent years. These secondary data sources are informative at the industry and sector level, allowing for a general mapping of activities at different levels of a supply chain, but they do not facilitate the identification of specific companies or their connections with other market operators.

Several approaches exist for collecting primary data, but despite the significant resources required, identifying buyer-supplier relationships is not always guaranteed. For instance, the analysis method

proposed by Fredrik in 2019 identifies companies involved at different levels for a specific country, such as Costa Rica's medical industry, but lacks data on company connections. Similarly, the model proposed by van den Brink et al. in 2020 maps cobalt supply chains using only secondary data, like industry statistics and mining sites, without identifying supplier-buyer relationships. Recent studies are refining manual data extraction and analysis tools from unstructured texts using natural language processing (NLP), as proposed by Wichmann in 2020. However, these methods are still developing and suffer from low coverage, mainly due to the absence of large, labeled datasets and potential selection bias since not all supplier-buyer relationships are mentioned in public company documents.

These buyer-supplier relationship data are valuable but difficult to collect and extract. For this reason, several data providers are developing and expanding supply chain-specific curated databases, such as Mergent Online, Compustat Supply Chain Suite, Factset Revere Supply Chain, and Bloomberg SLPC. The latter two provide globally covered datasets, enriched through continuous expert review. Specifically for the U.S. market, essential data sources are the 8-K, 10-K, and 10-Q filings, which contain the names of major suppliers as required by the Securities and Exchange Commission (SEC).

Using curated supply chain datasets and integrating data from primary and secondary sources, it is possible to map supply networks at the industry level, including connections between companies operating in a selected sector or group of related sectors. An enterprise-centered supply network can be generated through snowball sampling. However, this method also has limitations, particularly the inability to disambiguate higher-order relationships from such databases. Ultimately, it can be stated that the mentioned multi-industry databases do not provide information on product flows connected through a bill of materials structure. They are extremely useful for supply network mapping but not entirely reliable for supply chain mapping. Only through specialized databases can product-level supply chain data be obtained, such as Marklines for the automotive sector, whose current coverage is still limited to the first tier.<sup>66</sup>

- *Addressing Mapping Challenges*

Detailed supply chain mapping is a complex process that requires the active involvement of the main company and the collaboration of its suppliers and customers. Even when information is available, the task is often laborious and can be limited to the structural dimension, i.e., identifying who is connected

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<sup>66</sup> Bart L. MacCarthy, Wafaa A.H. Ahmed, G.Demirel. (2022). Mapping the supply chain: why, what and how?. International Journal of Production Economics. Pp. 3-6.

to whom. A major challenge is obtaining data on higher-tier suppliers, which can be impossible to achieve with primary sources. In such cases, secondary commercial databases are necessary.

However, secondary sources have significant limitations. They may not accurately reveal product flow chains beyond immediate connections. This type of information is crucial for a comprehensive supply chain map as it helps understand hierarchical relationships within the supply chain. To address this challenge, companies are advised to start with secondary data sources for macro-level global value chains or micro-level industry supply networks, then add or remove nodes and links based on the best available knowledge.

Another fundamental element to consider is the highly dynamic nature of supply chains. Conditions can change rapidly, making a supply chain map obsolete in a short time. Therefore, the timeliness of information is crucial but difficult to achieve. Emerging digital technologies, such as digital twins, control towers, and blockchain, offer advanced solutions for rapidly collecting, updating, and integrating data. These technologies allow for near real-time mapping and visualization of supply networks, significantly improving supply chain management. Additionally, network science and systems dynamics methods can be used to analyze and visualize these dynamic networks. However, the adoption of these advanced technologies and methodologies is still in the development and implementation phase. Combining data from primary and secondary sources and integrating them through advanced analytical tools can significantly improve the accuracy and timeliness of mappings.

In conclusion, supply chain mapping is an essential but complex process influenced by many variables and challenges. Combining primary and secondary data sources, using emerging digital technologies and advanced analytical methods, can provide a more robust and accurate solution for understanding global supply chains. However, it remains crucial to continue developing and refining these tools to address the inherent difficulties of this process and ensure that companies can effectively manage their supply networks.

### *3.4.2 Visualization and Mapping of the Supply Chain: Methodology and Tools*

To obtain a transparent overview of organizations and related processes, supply chain mapping must be described and visualized at any level of the hierarchy. The first phase of the methodology consists of providing a map of the supply chain under analysis, developed in pictorial form using diagrams. The map must capture essential information for each supply chain entity, including the products and materials

sourced or purchased, costs and prices, quantities, replenishment times, and identification of unique sources or key customers. Information sources must be provided by each supply chain entity.

Supply chain maps allow for the identification of major constraints, the relative importance of each entity, their key characteristics, supply chain dynamics, and its complexity. Complexity depends on both the entities that comprise it and the material flow that circulates among them. A supply chain map illustrates the key processes to improve the supply chain's resilience to potential disruptions. For effective mapping, six main dimensions must be considered: supply chain entities, relational links between entities, material flows, information flows, management policies, and delivery times.

Some of the desired visual properties of supply chain maps have been discussed in existing literature, particularly in studies proposed by Farris (2010), Gardner and Cooper (2003), Nuss et al. (2016), and van den Brink (2020). Farris (2010)<sup>67</sup> illustrates graph decoration by modifying node sizes and edge widths to reflect their attributes, using different symbols for various types of entities. Nuss et al. (2016)<sup>68</sup> and van den Brink et al. (2020)<sup>69</sup> provide visualization examples to identify at-risk suppliers in supply networks. Although standardization of icons has been recommended multiple times in these studies, it has not been pursued in the literature, particularly for strategic mapping.

Discussing the principles of visualization is beyond the scope of this article, but it is worth citing the foundational work of Edward Tufte (1983)<sup>70</sup>, who emphasizes the importance of representing data faithfully and effectively, focusing on the key characteristics highlighted by the data without adding "graphical junk." The choice of visualization software tools depends on the analyst's technical skills, familiarity with the software, and the study's purpose. At the lower levels of the hierarchy, the map objects are fewer but more varied due to the greater granularity of the data. For Visual Stream Mapping (VSM), icons have been standardized, and diagramming software like Microsoft Visio can be used.

For supply network mapping, complexity increases with the number of items represented. An effective strategy involves highlighting important nodes by setting their size proportionally to the company's size, market share, or network centrality. Important links can be represented using thicker edges to indicate a

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<sup>67</sup> Farris, T.M. (2010). *Solutions to strategic supply chain mapping issues*. Int. J. Phys. Distrib. Logist. Manag. 40, 164- 180

<sup>68</sup> Nuss, P., Graedel, T.E., Alonso, E., Carroll, A. (2016). *Mapping supply chain risk by network analysis of product platforms*. Sustain. Mater. Technol. 10, 14–22.

<sup>69</sup> van den Brink, S., Kleijn, R., Sprecher, B., Tukker, A. (2020). *Identifying supply risks by mapping the cobalt supply chain*. Resour. Conserv. Recycl. 156, 104743

<sup>70</sup> Tufte, E. (1983). *The Visual Display of Quantitative Information, second ed.* Graphic Press, Cheshire, Connecticut USA.



higher transaction value. Additionally, coloring nodes based on their belonging to network communities is useful for representing meso-scale network structures.

There are several tools for network analysis, ranging from packages in general programming languages like R and Python (iGraph and NetworkX packages) to specialized software with user interfaces like Gephi, Pajek, and Ucinet (see Demirel, 2022, for a review). Combining these tools with collected data allows for detailed and dynamic supply chain mapping, improving the management and resilience of supply networks.

In conclusion, supply chain mapping is an essential process for understanding connections and flows within supply networks. Adopting advanced visualization methodologies and using specialized software tools can significantly improve the accuracy and timeliness of mappings, facilitating more effective and resilient global supply chain management.

### **3.5 Identification of Criticalities and Supply Chain Risk Management (SCRM)**

Once the company has mapped the supply chain to the desired and useful level of detail, it will be able to identify existing criticalities and its exposure to exogenous risks, the subject of this study. Only at this point, having an accurate understanding of their current situation, can companies effectively implement SCRM (Supply Chain Risk Management) policies. SCRM refers to the implementation of strategies to manage supply chain networks through continuous risk assessment and vulnerability reduction. In an increasingly globalized and interconnected context, continuous monitoring of these risks and their assessment on the supply chain is essential for long-term business success. The growing complexity and interdependence of modern supply chains increase exposure to risks, making a systemic approach indispensable for identifying, assessing, and mitigating these risks.

Risk inherently contains a degree of uncertainty. Although certain probabilities can be assigned, uncertainty cannot be quantified. However, these uncertainties can be minimized with adequate assessment and planning. Regarding this, SCRM can be divided into two main categories of approaches. The first is a comprehensive risk management strategy, while the second is an approach aimed at a specific disruption. These specific disruptions are those presented in the second chapter, such as terrorist attacks, security, and delivery times. The study proposed by A. Gurtu and J. Johnny titled "Supply Chain Risk Management: Literature Review" proposes a theoretical background on the subject, dividing SCRM into four macro categories:

- A. Risk definition
- B. Risk disruption
- C. Risk management
- D. Risk detection and mitigation

In this chapter, we will focus particularly on points C. and D., as they are directly related to the mapping and data collection phase of supply chains and networks. Point B. has already been extensively discussed in the second chapter of this thesis.<sup>71</sup>

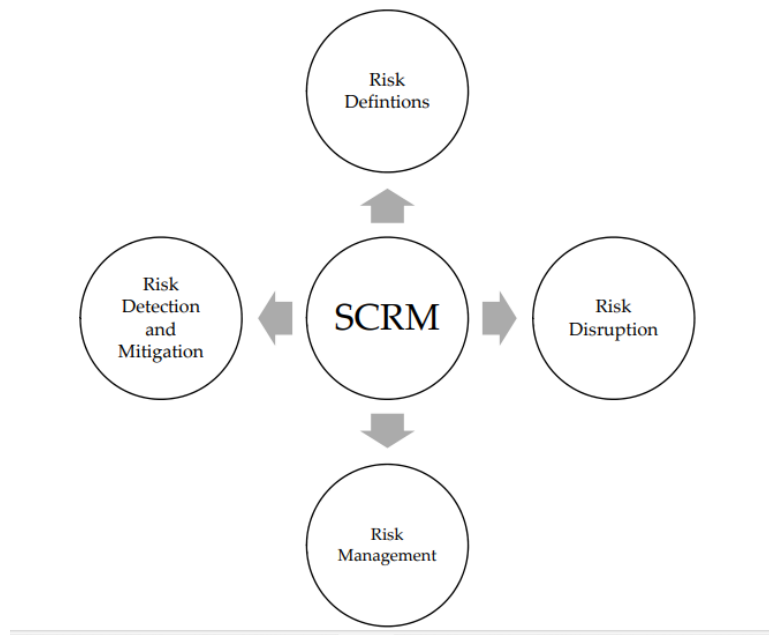


Image 24: Supply chain risk management (SCRM) categories. (Source: Amulya Gurtu, Jestin Johny. (2021). *Supply Chain Risk Management: Literature Review*. MDPI. Pp. 1-16.)

### 3.5.1 Risk Management

Risk management is fundamental to achieving business objectives, whether short-term or long-term. Therefore, management is described as a set of strategies, methods, and supporting tools to identify and control risks to an acceptable level. The ultimate goal is to enable the decision-maker to understand and evaluate the impact of risk in a supply chain network. Another definition could be that risk

<sup>71</sup> Amulya Gurtu, Jestin Johny. (2021). *Supply Chain Risk Management: Literature Review*. MDPI. Pp. 1-16.

management is a synchronized set of actions and approaches to direct an organization to minimize risk and achieve its objectives.

At the supply chain and network level, it is interesting to analyze a benchmark market to visualize different risk identification methods. The study "Identifying Tools and Methods for Risk Identification and Assessment in Construction Supply Chain" proposed by H. Hernadewita and B. I. Saleh, highlights four different methods for identifying these risks in the construction sector, analyzing the supply chains of this sector:

1. Analytical Hierarchy Process (AHP)
2. Failure Mode and Effect Analysis (FMEA)
3. Supply Chain Operations Reference (SCOR)
4. Hazard and Operability (HAZOP)

Mapping and visualization of supply chains are essential for developing and applying these risk assessment methodologies. They provide a clear and comprehensible overview of different flows, facilitating the identification of various criticalities. It is important to mention that these identification methods are useful for a broader range of risks than those covered in this thesis. However, discussing these different methods is still useful for companies that want to preemptively assess their exposure to disruptive factors, focusing and calibrating these tools on external factors such as wars, terrorism, and global pandemics.<sup>72</sup>

### 1. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a methodical approach designed to organize and analyze complex decision scenarios. This technique, rooted in mathematics and psychology, was introduced by Thomas L. Saaty in the 1970s. In the context of the construction supply chain, AHP is used to prioritize risks by breaking down a problem into a hierarchy of more manageable sub-problems, each of which can be analyzed individually.

To effectively implement AHP, the process begins with defining the problem and determining the specific knowledge required. The next step involves structuring the hierarchy from the top, representing the overall goal of the problem, through intermediate levels that include the criteria influencing the subsequent levels, down to the lowest level, which consists of a list of alternatives. For each level, a

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<sup>72</sup> H. Hernadewita, B. I. Saleh. (2021). *Identifying Tools and Methods for Risk Identification and Assessment in Construction Supply Chain*. International Journal of Engineering. Vol. 33, No. 7.

series of pairwise comparison matrices are constructed. These matrices, typically  $n \times n$  in size, allow comparing elements of a given level with the criteria of the immediately higher level.

After constructing these matrices, pairwise comparisons are used to derive a set of priorities within the hierarchy. This phase ensures an accurate assessment of the relative importance of each element. The final phase of the process involves verifying the consistency of the judgments to ensure that the comparisons are logically valid.

The advantages of AHP in the construction supply chain include facilitating decision-making involving multiple criteria and providing a clear rationale for the decisions made. However, there are also notable disadvantages. The subjectivity inherent in judgments can introduce biases, and the method can become increasingly complex with a growing number of elements. Despite these challenges, AHP remains a powerful tool for prioritizing risks and making informed decisions in complex scenarios.

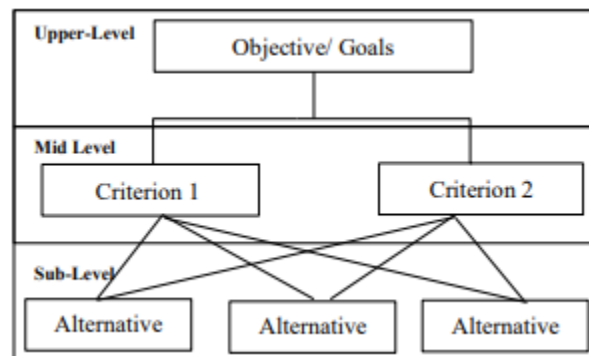


Image 25: A standard hierarchical structure sample for AHP (Source H. Hernadewita, B. I. Saleh. (2021). *Identifying Tools and Methods for Risk Identification and Assessment in Construction Supply Chain*. International Journal of Engineering. Vol. 33, No. 7.)

## 2. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a systematic and structured method for identifying potential failures within a project, production or assembly process, product, or service. Using a step-by-step approach, FMEA aims to clarify all possible failure modes, allowing for an evaluation of their relative impact. In the context of the construction supply chain, FMEA is crucial for identifying potential failure points and assessing the consequences of such failures.

Implementing FMEA begins with a comprehensive list of the steps involved in the process, followed by identifying potential failure modes for each step. Once these failure modes are outlined, the next phase involves identifying the effects of these failures and assigning a severity score to each, based on an agreed-upon scale. Next, the causes of these failures are identified, and their likelihood of occurrence is assessed. Additionally, the controls currently in place to detect these failures are identified, and their effectiveness is evaluated accordingly.

The culmination of this process is the calculation of the Risk Priority Number (RPN), obtained by multiplying the severity, occurrence, and detection ratings. This calculation allows prioritizing failure modes, identifying those requiring immediate attention. The final phase of the FMEA process involves developing and implementing actions to reduce the identified risks.

The primary advantages of FMEA are its proactive nature, which facilitates anticipating and preventing failures, and its utility in prioritizing issues based on severity, occurrence, and detection scores. However, the method is not without drawbacks. The FMEA process can be time-consuming and requires a detailed understanding of the process under analysis. Additionally, the subjective nature of assigning scores can lead to inconsistencies, potentially compromising the reliability of the results. Despite these challenges, FMEA remains a widely respected tool in risk management, providing a structured framework for identifying and addressing potential failures within the construction supply chain.

### 3. Supply Chain Operations Reference (SCOR)

This method, also useful in the construction sector as analyzed in this study, was previously discussed in the first chapter of this thesis. To avoid repetition on the structure of this method, only its advantages and issues in use will be highlighted.

One of the main advantages of the SCOR model is its standardized approach to supply chain management. This standardization provides a clear and consistent framework for performance measurement, allowing organizations to compare their processes with industry best practices. Additionally, the comprehensive nature of the SCOR model ensures that all aspects of the supply chain are considered, promoting a holistic view of supply chain management.

However, the SCOR model is not without challenges. Its effective implementation requires a thorough understanding of the model and significant training, as the complexity of the processes can be daunting. Furthermore, the detailed nature of the SCOR model can make its application labor-intensive and time-consuming, particularly for large and intricate supply chains like those in construction projects.

Despite these challenges, the SCOR model remains a valuable tool for organizations seeking to optimize supply chain operations. Providing a structured framework for process evaluation and risk mitigation allows organizations to improve their supply chain performance, contributing to the overall success and sustainability of their construction projects.

#### 4. Hazard and Operability (HAZOP)

Hazard and Operability (HAZOP) study is a meticulous and systematic methodology designed to identify and evaluate potential risks in both planned and existing processes. Initially developed for the chemical process industry, HAZOP has since been adapted for use in various sectors, including the construction supply chain, where it plays a crucial role in risk assessment by identifying hazards and operability problems that could impact personnel, equipment, and overall project outcomes.

Implementing a HAZOP study begins with clearly defining the objectives and scope of the analysis. This crucial phase ensures that the study is focused and relevant to the specific processes under examination. Subsequently, the process stages are meticulously identified and mapped in a detailed flow diagram. This diagram serves as a visual representation of the sequence of operations, facilitating a comprehensive understanding of the process flow and its potential breakpoints.

A multidisciplinary team is then assembled to conduct the HAZOP sessions. The diversity of expertise within this team is vital, as it brings together various perspectives and areas of knowledge, thereby enhancing the completeness of the analysis. During these sessions, the team systematically examines each process stage to identify potential deviations from the expected design or operational parameters. These deviations, known as guide words, help uncover possible hazards or operability issues that could arise under various scenarios.

Once deviations are identified, the team analyzes the causes and potential consequences of each. This analysis involves assessing the likelihood of occurrence and the severity of the impact, which helps prioritize risks that require immediate attention. Based on this assessment, the team develops actions and recommendations to mitigate or eliminate the identified risks. These actions may include process modifications, the implementation of additional safety measures, or changes in operating procedures.

The main advantages of the HAZOP methodology lie in its comprehensive and systematic approach. By involving a multidisciplinary team, HAZOP provides a holistic view of the process, ensuring that all potential risks are considered. This thoroughness is particularly beneficial in complex supply chains, where multiple interdependencies and variables exist.

However, the HAZOP process also presents some challenges. It is inherently time-consuming and requires significant resources, both in terms of personnel and detailed process information. The need for accurate and complete data is crucial, as any gaps or inaccuracies can compromise the effectiveness of the study. Despite these challenges, the HAZOP methodology remains a highly regarded tool for risk identification and assessment, offering a structured framework that enhances the safety and operability of construction supply chain processes.

As evidenced by the development of these various methodologies, they integrate and complement the mapping of supply chain processes at both network and structural levels. These tools are not only complementary and supportive but also complete the evaluation and understanding of the supply chain itself. They thus become an integral part of building TO-BE models, which will be constructed based on the criticalities that emerge both at the flow level (whether physical or informational, visualized through the mapping phase) and the risk exposure identified in the SCRM phase.

### *3.5.2 Risk Detection and Mitigation Strategies*

This point encompasses both the identification and mitigation phases of risk. Risk detection plays a fundamental role as a preventive tool for disruptions, particularly those due to force majeure, which are difficult to manage but can be estimated through various strategies. The mapping-based risk detection method of supply chains is a valuable tool for the risk detection phase, thanks to the possibility of visualizing different flows and their geographical location. As in the previous Risk Management phase, mapping can be integrated with other tools to offer companies a basket of tools useful for a more effective understanding of the operating environment. Some of these analytical tools, widely discussed in the literature, are:

#### 1. PESTEL Analysis

This is a strategic analysis tool used to evaluate external factors that can influence an organization. The acronym PESTEL stands for six categories of factors:<sup>73</sup>

- **Political:** Includes government policies, government stability, regulations, and legislation that can influence business.

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<sup>73</sup> Zaid Bin Mat Yusop. (2018). *PESTEL Analysis*. 1st National Conference on Multidisciplinary Research and Practice 2018. Pp. 34-38.

- **Economic:** Pertains to the economy in general, such as inflation rates, exchange rates, economic growth, and economic conditions that can affect demand and supply.
- **Sociocultural:** Considers social, demographic, cultural trends and changes in consumer behaviors that can impact the market.
- **Technological:** Includes technological innovations, research and development, automation, and other technologies that can improve or disrupt the sector.
- **Environmental:** Analyzes ecological factors such as climate change, environmental regulations, and the availability of natural resources.
- **Legal:** Comprises sector-specific laws and regulations, intellectual property protection, labor laws, and other legal regulations that can influence the company.

## 2. Comparative Country Risk Table

A comparative country risk table is a tool used to evaluate and compare the risks associated with investments in different countries. These risks can include political, economic, sociocultural, technological, legal, and environmental factors. The table provides a visual overview of the level of risk in various countries, allowing investors to make informed decisions based on a systematic assessment of each country's conditions. Generally, it can be defined as an evolution of PESTEL tables, integrated with evaluations including indices and reports from rating agencies such as Coface, Atradius, and international organizations like the International Monetary Fund (IMF) and the Organisation for Economic Co-operation and Development (OECD).

These two tools do not replace the mapping phases and other risk assessment tools discussed so far but integrate and support the decision-making process.

As for risk mitigation, this phase will be discussed in the next chapter. Once the criticalities of the investigated supply network or chain are identified, it is possible to implement preventive and structural mitigation policies. By redesigning flows and integrating them with corporate best practices and the use of new technologies, it is possible to build a supply chain as resilient as possible to unpredictable and disruptive events as analyzed. Only by making supply chains efficient through continuous monitoring and strategic management can companies be competitive in responding to these exogenous factors.



## CHAPTER FOUR

### **Interviews with Industry Experts on the Impact of Exogenous Factors on Supply Chains and Mitigation and Resilience Tools, with a Focus on New Technologies**

Throughout this thesis, a comprehensive overview of the concept of supply chain and the importance of effective management has been provided, particularly in relation to uncertainties arising from the operational and geographical environment in which these chains operate. In the first chapter, the concept of supply chain and supply chain management was discussed and presented, offering both terminological and historical context, as well as a conceptual framework within the current economic and business context. The second chapter focused on the concept of risk, particularly exogenous risk. An overview and classification of different types and cases were provided, along with an overview of the main dangers for supply chains both in the current year and as forecasts in the medium to long term. An empirical analysis offered by a study from the ECB on the impact of the COVID-19 pandemic on supply chains was also presented, highlighting the disruptive capacity of such events. The third chapter focused on the mapping phase and implementation of risk assessment methodologies. The importance of this phase was defined as a critical moment for understanding the operational environment in which supply chains are embedded, thus allowing for the identification of bottlenecks and potential exposures to the critical issues identified in the previous chapter. Various mapping methods were discussed and how to develop them was understood. Furthermore, once the map was visualized, the phases of risk management and risk detection and mitigation were defined. These phases allow for a 360-degree identification of risks and exposures, but since this thesis is focused on a particular risk case, these assessment tools were presented in this context.

This concluding fourth chapter of the thesis will focus on analyzing the outputs generated from the responses of various subject matter experts. The study aims to evaluate and integrate the review of the scientific literature on the subject conducted up to this point, but also to provide an overview of the physical and technological solutions that companies use. The interviews will allow this study to gain a deeper understanding of current risk phenomena for supply chains and the various tools for mitigating and optimizing current operational structures.

The interviewees all come from the consulting world, with varied academic and professional backgrounds but a common trend: the study and consultancy in the field of supply chain management.

Therefore, analyzing these responses is interesting because the inputs come from individuals who constantly apply the subject and across different industries, allowing for the identification of common trends and peculiarities among various sectors.

## 4.1 Research Methodology

### 4.1.1 Research Objective

This study aims to deeply investigate the topics covered in this thesis. Specifically, the interviews conducted for data collection aim to gather qualitative outputs on the following themes:

- Exogenous Factors and Supply Chain
- Resilience and Optimization of Supply Chains
- Current and Future Trends
- New Technologies and Supply Chain
- Global Scenarios and Impact on Supply Chains

By analyzing the collected data, it will be possible to evaluate the presence of clusters and common elements among the various responses, as well as assess any discrepancies between the scientific literature on the subject and the solutions proposed by consulting firms. The research methodology is based on several sources that specifically discuss qualitative investigation methods in supply chain management. Two sources in particular were used for the conduct of this investigation. The first is the one provided by the tipsheet on qualitative interview methods of Duke University<sup>74</sup>, which provides an overview of the techniques of conducting interviews and analysing qualitative data. The second, on the other hand, is that provided by Oxford Academic<sup>75</sup>, which offers interesting insights into the structured approach to qualitative research and also emphasises the importance of thematic analysis and contextual understanding in such studies.

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<sup>74</sup> S. Clifford. (2020). *TIPSHEET – QUALITATIVE INTERVIEWING*. DISM. Pp. 1-4.

<sup>75</sup> S. Brinkmann. (2023). *Qualitative interviewing: Conversational Knowledge Through Research Interviews*. Chapter 1: Introduction to qualitative interviewing. New York. Oxford Academic. 2nd Edition.

#### 4.1.2 *Sample Selection*

The selection criteria for conducting the interviews were:

- a) Sector Experience: Interviewees must have at least three years of experience in the supply chain consulting industry. This requirement ensures that they have a deep and practical understanding of the dynamics and challenges associated with supply chain management.
- b) Competence in Strategic Projects: They must have managed projects of strategic relevance in their field. This characteristic is crucial to ensure that interviewees can provide valuable insights into the issues discussed, based on concrete and high-level experiences.
- c) Diversity of Academic and Professional Background: It is preferable for interviewees to have a variety of academic and professional backgrounds. This allows a wider range of perspectives and opinions to be obtained, enriching the quality of the information gathered.
- d) Industrial Representation: Respondents should come from different industrial sectors within the supply chain. As far as size is concerned, the companies involved must have a supranational operating radius, with supply structures in several countries. There are no constraints on the type of industry of origin. Those criteria ensure that responses are not limited to a single industry perspective but reflect the various facets from different industries with an international outlook.

These criteria enabled the selection of individuals who were able to effectively answer the questions and obtain useful results for the critical analysis of the results. A total of three professionals were selected, two men and one woman aged between 27 and 40. Although they have different academic backgrounds as required by the selection criteria (the subjects are graduates in different disciplines, respectively in business administration, law and management engineering), they all work at the same consulting company and for the same business division. As far as industrial representation is concerned, they worked on projects in different industries, their division not being specialised but cross industries. This allowed them to have a diversified and comprehensive knowledge. The duration of the interviews were approximately 45 minutes each.

### 4.1.3 Interview Structure

#### ▪ **Section 1: General Information**

##### 1. Position and Role:

- Which consulting firm do you work for? What is your current position in your consulting firm?
- How long have you been working in supply chain consulting?

##### 2. Experience and Skills:

- In which specific sectors have you specialized?
- Could you briefly describe a recent supply chain optimization project you have worked on?

#### ▪ **Section 2: Exogenous Factors and Supply Chain**

##### 3. Impact of Exogenous Factors:

- How have recent global events (e.g., COVID-19 pandemic, geopolitical tensions) affected your clients' supply chains?
- Which exogenous factors do you find most disruptive to supply chains, and why?

##### 4. Risk Identification:

- What methodologies do you and your team use to identify risks in your clients' supply chains?
- Could you provide an example of a risk identification process you have implemented in one of your projects?

##### 5. Risk Management Strategies:

- What risk management strategies have you found most effective in mitigating the impact of these factors?
- How are risks prioritized for your clients?

#### ▪ **Section 3: Resilience and Optimization of Supply Chains**

##### 6. Building Resilience:

- What are the key elements of a resilient supply chain?
- How would you assist a client looking to improve their supply chain resilience? What should they focus on?

##### 7. Optimization Techniques:

- Which supply chain optimization techniques have you found most effective?
- How do you measure the success of optimization efforts?

8. Case Studies:

- Could you describe a successful case where you helped a client optimize their supply chain?
- What were the main challenges and how were they overcome

▪ **Section 4: Current and Future Trends**

9. Emerging Trends:

- What are the current trends in supply chain management that companies should be aware of?
- How do you foresee these trends evolving in the medium to long term (5-10 years)?

10. Future Challenges:

- What do you believe will be the most significant challenges for supply chains in the near future?
- How should companies prepare to address these challenges?

▪ **Section 5: New Technologies and Supply Chain**

11. Technology Adoption:

- How are new technologies (e.g., IoT, AI, blockchain) being adopted in your clients' supply chains? How have management techniques evolved, and consequently the technologies used? –
- Could you provide examples of successful technology implementations?

12. Impact of Technology:

- What impact do you believe these technologies will have on supply chain efficiency and resilience?
- Are there potential drawbacks or challenges associated with adopting these technologies?

▪ **Section 6: Global Scenarios and Impact on Supply Chains**

13. **Global Risk Scenario:**

- How do you perceive the current global risk scenario affecting supply chains? –

- Which global risks do you consider most critical for supply chain management? How do you foresee the future developments of this scenario?

#### 14. Strategic Recommendations:

- What strategic recommendations do you have for companies navigating the current and future global risk scenarios?
- How can companies balance the need for efficiency with the need for resilience in their supply chains?

#### *4.1.4 Interview Procedure*

The interviews were structured to allow the interviewee to provide open and unbiased responses. The interviews were conducted both in person and remotely using dedicated video calling software. The responses were recorded and analyzed through qualitative analysis conducted both manually and using qualitative data analysis software<sup>76</sup>. The data analysis allowed for the identification of common themes regarding resilience, optimization, current and future trends, the adoption of new technologies in the supply chain, and the impact of global scenarios.

#### *4.1.5 Data Analysis Methodology*

To effectively analyze the collected data, the study utilized qualitative data analysis software to code the responses. Thanks to the standardization of questions, the outputs were analyzed and coded through an iterative process of response analysis. Once the relevant text segments were coded, they were grouped and identified into broader themes. These themes emerged both from the data and from the questions posed.

By identifying the various themes that surfaced in the responses, it was possible to develop and group the themes to identify clusters of responses. A cluster represents a group of responses that share a common theme. This methodology allows for a pragmatic and replicable comparison of responses and clusters, enabling the identification of similarities and differences. Grouping common themes into

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<sup>76</sup> ChatGPT-4o

clusters helps evaluate the presence of common patterns and, more generally, understand their characteristics and peculiarities.

In the analysis of the results, all identified clusters will be described and interpreted. The main and complementary themes, common opinions, and key differences will be highlighted. Furthermore, it will be possible to evaluate the differences between the obtained responses and the scientific literature on the management and optimization of supply chains in the presence of exogenous externalities. A key focus of this work is to provide an overview of the current literature on the subject and to assess the actual application of scientific literature findings within various business realities.

## **4.2 Analysis of Results**

The analysis of the responses yielded eight clusters of common themes, each of which highlights different points of reflection and understanding regarding the approaches and focal areas for industry operators. The clusters that emerged from this analysis are:

1. Impact of Exogenous Factors and Global Risk Scenarios
2. Risk Identification and Management
3. Supply Chain Resilience
4. Emerging Technologies and Benefits
5. Challenges and Issues in Technology Implementation
6. Supply Chain Optimization
7. Emerging Trends and Future Challenges
8. Strategic Recommendations

### Cluster 1: Impact of Exogenous and Global Factors

The first cluster identified combines exogenous and global factors that influence supply chains, such as the COVID-19 pandemic, current geopolitical tensions, natural disasters linked to climate change, regulatory variations, and, more broadly, the political, economic, and climatic instability characteristic of recent years.

The interviews revealed several critical international issues related to the management of corporate supply chains. The COVID-19 pandemic marked a turning point in this regard. According to all the

interviewees, this event "profoundly influenced our clients' supply chains, causing supply disruptions and forcing companies to revise their sourcing and warehouse management strategies." Another interviewee highlighted how the pandemic had a "significant impact on business continuity, requiring immediate solutions not only for raw materials but also for warehouses." The data and statements recorded on this issue (as predicted) align with those presented in this thesis, as evidenced by the ECB study analyzed in the second chapter.<sup>77</sup> Despite the well-known disruptive effects, one of the interviewees noted that some positive externalities emerged during this period, as many companies were able to "leverage new channels."

Another key area of concern on the international stage is the Russo-Ukrainian conflict, due to its significant impact on factors such as raw materials, warehouses, trade routes, and the search for new suppliers. The analysis related to supply chains aligns with the challenges highlighted in the scientific literature. The studies most referenced on this issue include the WEF's 2024 Global Risks Report<sup>78</sup> and the study titled "Russia-Ukraine War and Risks to Global Supply Chains," published in the *International Journal of Mechanical Engineering*.<sup>79</sup>

The ongoing conflict between Israel and Palestinian factions is another point of concern, particularly due to its impact on the Suez Canal. Here, the main challenge lies in the redesign of trade routes and the management of increased costs and delivery times. Additionally, the possibility of the conflict expanding could impact other trade routes and regional partners in the area in the short to medium term.

In terms of trade tariffs, companies are paying particular attention. The upcoming U.S. elections could serve as a warning for European companies, given the protectionist policies of the 2016-2020 period. However, according to one expert, "it is too early to assess the impact a priori. Our clients are aware of the various risks on the global stage, including the possibility of adverse tariff policies, and are preparing for different future scenarios."

Regarding natural events, they are unpredictable and can have potentially damaging effects. It is highly likely that future events will significantly challenge the supply chains of client companies, such as the hurricane that struck Japan in 2011 and damaged the Fukushima nuclear plant.

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<sup>77</sup> ECB. (2021). *Economic Bulletin*.

<sup>78</sup> World Economic Forum. (2023). *The Global Risk Report 2024, 19th Edition*.

<sup>79</sup> Nguyen Minh N., Dinh Thanh Dinh Thanh., Nguyen Hoang T., (2022). *Russia-Ukraine war and risks to global supply chains*. *International Journal of Mechanical Engineering*. Pp. 636-637.GLOBAL



This cluster highlights that the challenges identified during the theoretical background in this thesis are consistent with the concerns raised by experts. However, the interviews did not indicate the relevance of misinformation as a major threat to international economies, as repeatedly emphasized in the 2024 Global Risk Report. This is likely due to the lower impact of this factor on supply chains compared to other more significant issues such as geopolitical and environmental crises.

### Cluster 2: Risk Identification and Management

This cluster focuses on the methodologies and strategies for risk identification and management. Among the various approaches cited, the development of flowcharts—mapping all business processes involved in supply chains—emerged as the most used and effective tool. According to experts, this tool is particularly valuable in identifying critical issues and bottlenecks because it "allows activities to be connected, identifying inputs, outputs, stoppages, and critical points." This position aligns with the scientific literature, as Gardner & Cooper (2003) noted that "mapping represents an effective tool to link business strategy to supply chain strategy, identifying both performance improvement opportunities and network redesign, as well as potential risks and criticalities."<sup>80</sup>

Machine learning tools to identify potential vulnerabilities also serve as complementary tools to flowcharts. The analysis of company data enables the development of scenario simulations, big data analysis, and real-time risk mapping tools. Based on the interviews, risk management strategies include a significant variety of digital and analog methodologies and tools. Other strategies identified in this study include the diversification of supply sources, the adoption of flexible contracts, and the reengineering of the supply chain to create a more agile structure.

However, the interview results indicate a discrepancy between the SCRM phase (Supply Chain Risk Management) and the theoretical background in this thesis. The methodological approach provided by the study "Supply Chain Risk Management: Literature Review"<sup>81</sup> diverges from the more operational approach offered by consulting firms. This discrepancy is likely due to the different objectives of the analyses conducted. The purely operational and client-driven approach of the interviewees contrasts with the more theoretical and holistic view offered by scientific studies on the subject.

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<sup>80</sup> Gardner, J.T., Cooper, M.C. (2003). *Strategic supply chain mapping approaches*. J. Bus. Logist. 24.

<sup>81</sup> Amulya Gurtu, Jestin Johny. (2021). *Supply Chain Risk Management: Literature Review*. MDPI.

As will be discussed later, the availability of data from companies is often insufficient or incompatible with the application of these new predictive analysis technologies. The interviews reveal a gap between the tools offered by scientific literature and those used by consulting firms.

### Cluster 3: Supply Chain Resilience

The third cluster identified explores the factors contributing to supply chain resilience, such as real-time visibility, strong partnerships, automation, diversification of routes and suppliers, the use of blockchain for traceability, and the ability to respond quickly to disruptions.

Real-time visibility is extremely fundamental. As highlighted during one of the interviews, visibility allows for more rapid and effective forecasting and management of the disruptive effects of exogenous factors. One interviewee noted, for example, that "with project management (PM), the more data we have, the better we can predict risks through tracking. Less visibility means a lower perception of risks." Real-time visibility across the entire value chain, supported by advanced technologies such as blockchain-based monitoring, is crucial for anticipating and mitigating risks. This factor was given significant importance in the interviews, though it appears less emphasized in the scientific literature compared to other elements considered complementary by the interviewees. Nonetheless, the literature offers a range of technologies and implementations aimed at improving company visibility. However, as will be seen in the analysis of the responses, there are currently physical and capacity limitations to the use of these technologies by companies.

Another critical factor is the creation of strong partnerships with the various suppliers and sub-suppliers involved in the different stages of the supply chain. The interviews revealed that this plays a decisive role in the ability to manage unforeseen events quickly and effectively.

These two elements identified in the interviews are also relevant to the application of optimization techniques. Only once a company has real-time visibility can it choose which methodologies to use and which solutions to apply in relation to the recorded data. This principle is clearly explained in the third chapter of this thesis. As cited in the text, "3.1 of their supply chain configuration to best address its impact on planning, management, and control of the supply chain (pg. 48)."

Finally, the diversification of transportation routes and the ability to respond quickly to disruptions are critical components of resilience. Companies that invest in these areas are better prepared to face potential crises and maintain operational continuity. The concept of resilience, therefore, is a central element in both the work of consulting firms and the scientific research on the subject.

#### Cluster 4: Emerging Technologies and Benefits

Emerging technologies are revolutionizing supply chain management. Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, and autonomous robotics are significantly enhancing operational efficiency, transparency, and supply chain responsiveness. As one interviewee noted, "New technologies, such as AI, help us identify at-risk shipments through data analysis. Real-time systems related to maritime and road traffic can improve efficiency, for example, by suggesting less costly routes or avoiding obstacles. Warehouse efficiency has also improved with GPS and IoT tags, similar to smart tracking."

An example of the application of these new technologies was provided by an interviewee who discussed the implementation of the Transportation Management System (TMS) in optimizing freight transport. According to the interview, the TMS "organizes and manages truck saturation, preventing them from departing half-empty, reducing costs, and selecting the most cost-effective carrier among those available. The TMS is an example of the efficient application of new technologies for supply chain optimization, even in the event of sudden blockages."

However, it is important to highlight a significant discrepancy between the application of these innovations in the literature and their actual use in operational reality. The next cluster will address the current challenges and difficulties companies face in applying and integrating new tools based on big data and blockchain.

#### Cluster 5: Challenges and Issues in Technology Implementation

Despite numerous benefits, the implementation of new technologies presents several challenges and faces significant critical issues due to various factors. Inefficient dataset management, high training and implementation costs, and the need for specialized skills are some of the main obstacles. In the near future, companies will need to address these challenges by developing training strategies and investing in appropriate technological infrastructures to maximize the benefits offered by emerging technologies.

While new technologies promise real-time visibility, critical analysis of the interviews suggests that many companies are not yet ready for full integration. This highlights a gap between the rapid pace of technological development and companies' ability to adapt to these changes, as noted by Lee (2021)<sup>82</sup>. The inability to bridge this gap could limit the benefits of adopting these technologies in the short term.

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<sup>82</sup> Neil Chueh-An Lee. (2021). *Reconciling integration and reconfiguration management approaches in the supply chain*. International Journal of production economics. Vol. 242.

Nonetheless, significant progress has been made in recent years, thanks to investments directed toward these tools.

The difficulty in operationalizing certain innovations within the business environment has made the role of consulting firms even more crucial in this sector. As one interviewee mentioned, "Consulting firms can help companies make the most of implementing these new technologies, offering a 360-degree view and analysis from the AS-IS phase to the TO-BE phase." However, these technologies have been described as "still niche" and accessible only to companies with significant financial and infrastructural resources.

In conclusion, this cluster underscores the limitations of widespread adoption of these technologies in the short term, both due to the inherent challenges of their implementation and the current shortcomings of companies in mastering the fundamentals. Despite the current situation, there are still successful examples, such as the spread of the TMS system. Additionally, companies are increasingly preparing themselves to efficiently and extensively integrate these innovations in the short to medium term.

#### Cluster 6: Supply Chain Optimization

Once the pain points and bottlenecks of supply chains have been identified, it becomes necessary to implement actions aimed at optimizing them to improve operational efficiency and reduce associated costs. Techniques such as predictive analysis, the use of optimization algorithms, and the integration of legacy systems are powerful tools for optimizing logistics processes, as highlighted by the interviewees. Collaboration with technology providers and reengineering internal processes also allow companies to reduce delivery times and improve demand forecasting accuracy.

Optimization is thus linked to the implementation of new technologies, but it is not solely dependent on them. A rationalization and improvement of processes at the design level can be just as useful and effective as implementing new tools, which can sometimes be costly both in terms of investment and in terms of training and integration within existing processes.

In enriching this thesis, the optimization methods proposed by the various experts are of great interest. In previous chapters, the different exogenous risks, the phase of understanding various supply flows, and the different SCRM methodologies were analyzed. However, the subsequent phase of addressing critical issues and optimizing processes is absent from this theoretical background. Further studies on this matter, to verify potential discrepancies between the proposals offered by academia and the solutions proposed by companies, are of great interest for further in-depth research.

## Cluster 7: Emerging Trends and Future Challenges

This cluster identifies two main drivers in future trends in supply chain management. The first concerns sustainability and social responsibility. As highlighted in the interviews, companies "are adopting green supply chain practices, such as using recycled materials and reducing carbon emissions, to respond to increasing regulatory pressures and civil society demands." Although the main trend remains the previously discussed rise of new technologies (such as big data analysis tools, blockchain, digital twin, etc.), environmental and sustainability issues are also predominant in the scientific literature. As cited in this report's third chapter, "sustainability has become a dominant concern. The growing awareness of environmental and social issues has led to stricter regulatory requirements for companies, while consumers, particularly Millennials and Generation Z, are increasingly interested in the origin and authenticity of products."

In this context, the main future challenges in green supply chain practices will include adapting to increasingly stringent environmental regulations and managing the complexity arising from the globalization of supply chains. Companies will need to prepare for these challenges by investing in advanced analysis technologies and building internal capabilities to respond quickly to regulatory changes.

The second driver of future trends relates to the application of new technologies for managing supply chains, a factor extensively discussed in previous clusters.

## Cluster 8: Strategic Recommendations

The final cluster summarizes the strategic recommendations proposed by the various experts. Given the highly fluid and uncertain international and climatic context, several key elements are suggested for companies to focus on to manage exogenous disruptions with potentially disruptive effects. These pillars can be summarized as:

- Real-time visibility
- Attention to all channels through which companies interface with customers, including both physical and online channels
- Leveraging new technologies, particularly for modeling alternative scenarios
- Building strong partnerships with various suppliers
- Developing operational continuity plans

The scientific literature on this subject focuses on several of these elements, albeit with a more academic and less operational approach. Some of the most interesting studies discussed in this thesis include Gardner & Cooper's "Strategic Supply Chain Mapping Approaches" and "Mapping the Supply Chain: Why, What, and How?" by Bart L. MacCarthy et al.<sup>83</sup> These studies (discussed in the third chapter) highlight the importance of mapping and data understanding as effective tools for managing unforeseen occurrences, but they fall short in explaining how such technologies and analysis methods can be integrated and managed within current corporate operational structures.

Through the study conducted via interviews with experts, it was possible to shed light on the practical difficulties companies face in not only applying new technologies but also in understanding the raw data from their own structures. The scientific literature provides a broad understanding of this subject, offering an overview of what corporate structures might look like in the near future.

#### 4.2.1 Summary Table of Interviews on Supply Chain Changes

The table below presents and summarises the main clusters that emerged from the interviews conducted, with the key findings and transformations identified in the supply chains. This diagram highlights the impact of different exogenous factors and new technologies on decision-making at the strategic level.

Cluster	Key Findings	Changes in Supply Chains
<b>1. Impact of Exogenous and Global Factors</b>	- COVID-19 pandemic significantly disrupted supply chains, forcing companies to revise sourcing and warehouse management strategies.	- Shift towards more flexible and localized sourcing strategies.
	- The Russo-Ukrainian conflict impacts raw materials, trade routes, and suppliers.	- Increased focus on diversifying suppliers and routes to mitigate geopolitical risks.

<sup>83</sup> Bart L. MacCarthy, Wafaa A.H. Ahmed, G.Demirel. (2022). *Mapping the supply chain: why, what and how?*. International Journal of Production Economics.

<b>2. Risk Identification and Management</b>	- Flowcharts are widely used to map supply chain processes and identify bottlenecks.	- Greater integration of digital tools (e.g., machine learning) for real-time risk assessment.
	- Machine learning tools complement flowcharts in vulnerability identification.	- Emphasis on mapping and data analysis to anticipate disruptions.
<b>3. Supply Chain Resilience</b>	- Real-time visibility is critical for forecasting and managing risks.	- Implementation of real-time tracking systems (e.g., blockchain) to enhance visibility.
	- Strong partnerships with suppliers are essential for quick response to disruptions.	- Strengthening supplier relationships to improve resilience.
<b>4. Emerging Technologies and Benefits</b>	- Technologies like AI, IoT, and blockchain are enhancing operational efficiency and transparency.	- Adoption of AI and IoT for predictive analysis and optimization.
	- Example: Transportation Management System (TMS) optimizes freight transport.	- Gradual integration of blockchain for improved traceability and transparency in the supply chain.
<b>5. Challenges and Issues in Technology Implementation</b>	- Challenges include inefficient dataset management, high training costs, and lack of specialized skills.	- Slow and gradual adoption of advanced technologies.
	- Many companies are not yet ready for full integration of new technologies.	- Increased investment in training and infrastructure to support technology integration.
<b>6. Supply Chain Optimization</b>	- Optimization linked to new technologies and process improvement at the design level.	- More precise and efficient logistics processes through predictive analysis and optimization algorithms.
	- Collaboration with technology providers to enhance demand forecasting and reduce delivery times.	- Reengineering of internal processes for better outcomes.

<b>7. Emerging Trends and Future Challenges</b>	- Sustainability and social responsibility are becoming central.	- Shift towards sustainable practices, driven by regulatory pressures and consumer demand.
	- Companies are adopting green supply chain practices, such as using recycled materials and reducing carbon emissions.	- Focus on reducing environmental impact and increasing transparency.
<b>8. Strategic Recommendations</b>	- Real-time visibility and strong supplier partnerships are key.	- Adoption of continuous monitoring and advanced modeling tools to predict and mitigate potential risks.
	- Companies should leverage new technologies for modeling alternative scenarios and develop operational continuity plans.	- Strategic focus on maintaining operational continuity.

The results of the interviews show a number of emerging trends in supply chains, which largely mirror the existing literature but also highlight some important discrepancies between theory and practice. The following is a detailed comparison between the results obtained and the academic literature.

- **Impact of exogenous factors:** The impact of the COVID-19 pandemic and geopolitical conflicts, such as the war in Ukraine, on the global supply chain is well documented in the literature. The study proposed by Christopher and Peck in 2004<sup>84</sup> highlight that global supply chains are particularly vulnerable to sudden and disruptive events. During the interviews, many companies found themselves unprepared for such events and forced to significantly revise their procurement strategies. This confirms the findings of previous studies<sup>85</sup> which highlight that companies often struggle to adapt quickly. However, the academic literature emphasizes more the urgency of

<sup>84</sup> Christopher M. (2005). *Supply Chain Management. Creare Valore con la Logistica*. Financial Times, Prentice Hall.

<sup>85</sup> D. Ivanov, A. Dolgui. (2020) *Viability of intertwined supply networks: extending the supply chain chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak*. International Journal of Production Research. Pp 2904-2915.



adopting diversification and localization strategies to mitigate exogenous risks<sup>86</sup>, while many companies surveyed are still in the transition phase. This gap between theory and practice suggests that the implementation of these strategies may require more time and resources than theory predicts, especially in industries with a strong dependence on global networks.

- Resilience and risk management: The resilience of supply chains emerged as a crucial topic in the interviews as well as in the literature. According to the survey proposed by Tang in 2006<sup>87</sup>, resilient supply chains can quickly adapt to disruptions while maintaining acceptable operational levels. The interviews confirmed this view, with experts emphasizing the importance of real-time visibility to enhance resilience. This is further supported by recent literature, which highlights how technologies such as blockchain and IoT can significantly improve the visibility and responsiveness of supply chains<sup>88</sup>. However, while theory pushes for immediate adoption of these technologies, technical difficulties, high costs, and organizational barriers represent significant obstacles. This confirms what was suggested by the findings of Handfield and Nichols<sup>89</sup>, who even then predicted that technological barriers were a limitation for the widespread adoption of new technologies but also indicated that collaboration with external suppliers and partners could be a strategy to overcome these difficulties.
- Emerging technologies: Emerging technologies, such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain, are considered key enablers for improving operational efficiency and transparency in supply chains. According to Wang et al. (2020)<sup>90</sup>, these technologies offer significant potential to optimize supply chain management through risk prediction and automated decision-making. The interviews confirm this trend, with a focus on the adoption of AI-based predictive tools to prevent disruptions. However, it was pointed out that one of the main obstacles is the lack of adequate skills to manage these technologies, a problem also highlighted by different studies, such as the one proposed by Lee et al. (2021)<sup>91</sup>. On the other hands, others and more

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<sup>86</sup> Y. Sheffi. (2001). *Supply Chain Management under the Threat of International Terrorism*. Massachusetts Institute of Technology. Vol. 2, Nr. 2. Pp. 1-11.

<sup>87</sup> Tang, C.S. (2006). *Perspectives in supply chain risk management*. International Journal of Production Economics. Vol. 103 No. 2, pp. 451-488.

<sup>88</sup> S. Saberi, M. Kouhizadeh, J. Sarkins. (2019). *Blockchain technology and its relations to sustainable supply chain management*. International journal of production research. Pp. 2117-2135.

<sup>89</sup> Robert B. Handfield, Ernest L. Nichols. (2002). *Supply chain redesign: Transforming supply chain into integrated value systems*. Ft Press.

<sup>90</sup> M. Wang, Y. Wu, B. Chen, M. Evans. (2020). *Blockchain and supply chain management: a new paradigm for supply chain integration and collaboration*. Operations and Supply Chain Management: An International Journal 14 (1), pp. 111-122.

<sup>91</sup> Neil Chueh-An Lee. (2021). *Reconciling integration and reconfiguration management approaches in the supply chain*. International Journal of production economics. Vol. 242

recent studies<sup>92</sup>, suggest that in addition to technical training, a cultural change is needed to integrate these technologies within organizations, promoting greater collaboration between different business functions. A practical example of this phenomenon is the adoption of blockchain by large logistics operators such as Maersk, which implemented the TradeLens platform to improve traceability and transparency in shipping operations. This type of solution is in line with what emerged from the interviews, where the growing importance of transparency in global supply chains is highlighted.<sup>93</sup>

- Challenges in implementation: The interviews revealed that inefficient data management and the lack of specialized expertise are the main challenges for the adoption of new technologies. This problem is widely discussed in the literature<sup>94</sup>, where it is highlighted that data complexity and high training costs limit the effective implementation of emerging technologies. One of those studies<sup>95</sup> emphasizes that technology alone is insufficient for success; it must be accompanied by cultural change and significant investment in staff training. This became clear during the interviews, where managers indicated that many companies struggle to find a balance between the adoption of advanced technology and adequate staff training. The companies that have successfully addressed this challenge, as in the case of Procter & Gamble<sup>96</sup>, have implemented continuous training programs and partnerships with universities to develop the necessary skills.
- Sustainability and social responsibility: Sustainability has become a central topic in supply chain management discussions. The study proposed by Carter and Rogers (2008)<sup>97</sup> point out that sustainable practices not only help reduce risks but also represent a competitive advantage for companies. However, the interviews reveal that the adoption of sustainable practices is often driven by regulatory pressure rather than strategic awareness. This is consistent with the results proposed by Seuring and Müller (2008)<sup>98</sup>, who suggest that sustainability is seen more as an

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<sup>92</sup> A. Gunasekeran, Samuel F. Wamba et al. (2017). *Big Data analytics and firm performance: Effects of dynamic capabilities*. Journal of business research. Pp. 356-365.

<sup>93</sup> N. Hackius, M. Petersen. (2017). *Blockchain in logistics and supply chain: Trick or treat?*. In proceeding of the Hamburg International Conference of Logistics. Pp. 3-18.

<sup>94</sup> A. Gunasekeran, Samuel F. Wamba et al. (2017). *Big Data analytics and firm performance: Effects of dynamic capabilities*. Journal of business research. Pp. 356-365.

<sup>95</sup> J. Heikkilä. (2002) *From supply to demand chain management: efficiency and customer satisfaction*. Journal of operations management. Pp 747-767.

<sup>96</sup> D. Elmuti. (2004). *Can management be taught? If so, what should management education curricula include?*. Management Decision. Pp. 439-453.

<sup>97</sup> Craig R. Carter, Dale S. Roger. (2008) *A framework of sustainable supply chain management: moving toward new theory*. International journal of physical distribution & logistic management. Pp. 360-387.

<sup>98</sup> S. Seuring, M. Müller. (2008). *From a literature review to a conceptual framework for sustainable supply chain management*. Journal of cleaner production. Pp. 1699-1710.

externally imposed necessity than a strategic choice. A concrete example is the carbon reduction initiatives taken by many companies, which are often implemented to comply with regulations rather than as an integral part of corporate strategy. However, leading companies such as Unilever have demonstrated that integrating sustainability into long-term strategy can lead to both environmental and economic benefits, increasing operational efficiency and enhancing corporate reputation.<sup>99</sup>

The results of the interviews highlight a growing awareness on the part of companies regarding exogenous risks and the importance of resilience in supply chains, in line with recent trends highlighted in the literature. However, significant gaps remain between theory and practice, especially regarding the adoption of technologies and the ability of companies to integrate them into their processes. Overcoming these barriers will require investment not only in technology infrastructure but also in staff skills development and increased collaboration with partners along the supply chain. In conclusion, the results of this study suggest that, in order to fully leverage new technologies, companies must not only invest in innovative tools but also rethink their organizational structures. This alignment between technology and structure is crucial for addressing future challenges and ensuring the resilience of supply chains.

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<sup>99</sup> P. Jones, D. Comfort, D. Hillier. (2017) *Managing materiality: Unilever and sustainability*, Journal of Public Affairs. 17(2), e1635.

## CONCLUSIONS

This thesis has analysed in depth and with a holistic approach the exogenous risks that threaten supply chains, highlighting their dangerousness and insidiousness for such structures. In fact, as highlighted in the course of the analysis carried out, if not managed correctly, these risks can seriously jeopardise the resilience and business continuity of companies. Concrete examples and a comprehensive classification of these risks were provided, based on the current scientific literature on the subject and on various reports drawn up by international financial institutions. Several key factors emerged, highlighting the need for an acceleration and radical overhaul of risk management strategies. Undoubtedly, the COVID-19 pandemic marked a fundamental turning point in the approach to the subject, but as highlighted in the course of this study, other exogenous shocks such as the war in Ukraine and tensions in the Middle East are increasing the difficulties of procurement and sourcing by companies. The analysis of the current international scenario has therefore highlighted the primary need for the companies involved to adopt a proactive and integrated approach to risk management, based on a thorough understanding of their supply chain and the adoption of advanced technologies.

Based on this, the supply chain mapping phase is one of the central elements of this thesis. A comprehensive review of the relevant scientific literature was proposed, where the need to collect and analyse data from different processes emerged. The utilisation and integration of data from both primary sources, together with methodologies for visualising the flowchart outputs obtained, appear to be fundamental elements for a full understanding of criticalities and possible bottlenecks.

It is precisely the ability to understand one's own structure that is central to the effective application of the various SCRM methodologies analysed. The scientific literature, on this element, has so far adopted a more academic and scholarly approach compared to the company's operational reality. In fact, although real-time visibility remains for both the central element for a rapid and effective reaction capability, the risk assessment and mitigation methods differ between the two realities. In particular, while methodologies such as the SCOR model and other modelling tools proposed in this paper are mainly used in the literature, a tendency to prefer other approaches has emerged in the reality of business consulting. The strategic recommendations offered by the experts primarily involve the ability to have visibility of data in real time, so as to be able to respond quickly to any unforeseen events. The exploitation of new technologies will, in the near future, be able to implement current calculation and

scenario building capabilities. Secondly, building strong partnerships with suppliers is another important element, given the fluidity and instability of the international environment. Other recommendations include the effective exploitation of all channels through which companies' interface with customers and the development of solid business continuity plans.

For companies, the insights proposed by this thesis paper are extremely interesting and relevant. Indeed, along with a solid review of the relevant scientific literature, the opinion of experts in the field is proposed on the elements analysed. This element allows for a discussion and critical evaluation of the results emerging from the literature. In particular, a discrepancy emerges precisely with regard to the application of new technologies. In fact, while the literature describes their characteristics and various potential benefits, the experts' opinions mitigate the actual benefits of their application. The lack of solid fundamentals and untrained personnel are major obstacles to their effective application. In this respect, it is highlighted that companies are investing in order to be able to adopt these technologies in the medium to long term in an effective and integrated manner with existing monitoring and control systems. In general, this thesis offers a whole series of best practices to operators in the sector who wish to implement their own management and control capabilities in their supply structures, delving into central themes that are, however, little discussed and analysed in an integrated manner in the current academic panorama.

The study encountered some objective limitations, linked in particular to the qualitative nature of this research and the limited availability of data on the disruptive effects of these exogenous variables on specific companies. Furthermore, the variability of global economic and political conditions could influence the universal applicability of the proposed strategies.

Despite these limitations, the thesis is a valuable tool for understanding and managing the challenges imposed by exogenous shocks that increasingly characterise the corporate operating environment. In particular, the research gap in the literature regarding the integration of new technologies in supply chain management to increase resilience and visibility against disruptions from exogenous factors is filled. Furthermore, this dissertation aims to stimulate and implement future directions of research and practice in the field of supply chain management. As such, future study on the current state of monitoring and control technologies used by companies, the impact and ability to increase real-time visibility of companies in this field, and the study of the role of sustainability in supply chain decisions is recommended.

Readers interested in increasing their knowledge on this subject are therefore advised to first understand their own operating environment and structure, which is not always easy and can sometimes be extremely laborious. It is precisely for these reasons that best practices to apply and a global overview of risks are proposed, also with reference to the current year. In addition, readers are invited to assess their own fundamentals, particularly in the management and analysis of data from their own facilities and the availability of personnel highly trained in the use of these new technologies. Although they represent the future in terms of data visibility, significant financial and infrastructural investments are needed. Therefore, this study is an invitation to those interested in this subject to reflect on their own structure and their medium to long term goals.

In conclusion, supply chain management is central to companies' operations, especially in an international context of increasing uncertainty. At the same time, new technological trends offer possibilities and management horizons that were unthinkable a few years ago. Precisely because of this, the integration of these innovations, together with management and organisational best practices, will be the future drivers of the supply chain, significantly increasing its ability to respond to increasingly numerous and unpredictable crises and threats.

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