Developing Supply Chain Resilience: A Case Study

Tomi Hardén

2023 Laurea

Laurea University of Applied Sciences

Developing Supply Chain Resilience: A Case Study

Tomi Hardén

Security Management

Master's Thesis

May, 2023

Laurea-ammattikorkeakoulu **Tiivistelmä**

Turvallisuusjohtaminen

Tradenomi (YAMK)

Tomi Hardén

Tapaustutkimus toimitusketjun resilienssin kehittämisestä

Vuosi 2023 Sivumäärä 80

Nykyaikaiset yhteiskunnat ovat riippuvaisia toimivista tuotteiden ja palveluiden toimitusketjuista. Valitettavasti toimitusketjut ovat usein alttiita sisäisille ja ulkoisille häiriöille, kuten koronaviruspandemia, puolijohdepula ja Ukrainan sota ovat osoittaneet. Siksi toimitusketjujen resilienssi on tärkeä aihe, jolla on laaja yhteiskunnallinen merkitys.

Opinnäytetyön ensimmäisenä tavoitteena on selvittää, mitä toimitusketjun resilienssi tarkoittaa kohdeorganisaatiolle. Toisena tavoitteena on tutkia, mitkä tekijät vaikuttavat toimitusketjun resilienssiin kohdeorganisaatiossa. Opinnäytetyön kolmantena ja viimeisenä tavoitteena ymmärtää, miten kohdeorganisaatio voi kehittää toimitusketjun resilienssiä.

Tiedot kerättiin pääasiassa 20 puolistrukturoidulla haastattelulla. Haastattelut koodattiin ja analysoitiin Gioia-menetelmällä. Tutkimuksessa käytettiin lisäksi valikoituja yrityksen sisäisiä esitysmateriaaleja.

Analyysin tuloksena saatiin tutkimuksen kohteena olevalle organisaatiolle oma toimitusketjun resilienssimääritelmä ja havaintoja toimitusketjun resilienssiin vaikuttavista tekijöistä. Tutkimuksessa ehdotetaan havaintojen perusteella toimia, joilla voidaan kehittää kohdeorganisaation toimitusketjun resilienssiä systemaattisesti pitkällä aikavälillä. Eräs ehdotuksista on rakentaa ja ottaa käyttöön toimitusketjun resilienssin kypsyysmalli, joka perustuu Alin, Mahfouzin ja Arishan (2017) toimitusketjun kestävyyden viitekehykseen.

Toimitusketjun kestävyys ei ole pysyvä olotila, vaan se kehittyy organisaation ja liiketoimintaympäristön mukana. Havainnot ja kehitysehdotukset soveltuvat pääasiassa tapausorganisaatioon, mutta ne voivat hyödyttää myös muita organisaatioita, jotka ovat kiinnostuneita toimitusketjun resilienssin kehittämisestä toimialasta riippumatta.

Asiasanat: toimitusketju, resilienssi, toimitusketjun resilienssi

Laurea University of Applied Sciences **Abstract**

Degree Programme in Security Management

Master of Business Administration (MBA)

Tomi Hardén

Developing Supply Chain Resilience: A Case Study

Year 2023 Number of pages 80

Modern societies depend on functioning supply chains for products and services. Unfortunately, supply chains are often vulnerable to internal and external disruptions, as demonstrated by the coronavirus pandemic, the semiconductor shortage, and the war in Ukraine. Therefore, supply chain resilience is an essential topic with broad societal significance.

The first goal of the thesis is to find out what supply chain resilience means to the case organization. The second goal is to investigate which factors affect the supply chain resilience of the case organization. The third and final goal of the thesis is to understand how the case organization can develop its supply chain resilience.

The data were mainly collected through 20 semi-structured interviews. The interviews were coded and analyzed using the Gioia method. In addition, selected internal company presentation materials were used in the study.

As a result of the analysis, the case organization’s supply chain definition and observations about factors influencing supply chain resilience emerged. Based on these factors, the research proposes actions that can help the case organization systematically develop its supply chain resilience in the long term. One of the proposals is to build and adopt a supply chain resilience maturity model based on Ali, Mahfouz, and Arisha's (2017) supply chain resilience framework.

Supply chain resilience is not static but develops with the organization and business environment. The findings and development proposals are mainly applicable to the case organization. However, those can also benefit other organizations interested in developing supply chain resilience regardless of industry.

Keywords: supply chain, resilience, supply chain resilience

Contents

1 Introduction

1.1 Research topic

The research topic of the thesis is supply chain resilience. It is a current and relevant topic with broad societal significance because modern societies depend on functioning supply chains. Unfortunately, supply chains are subject to internal and external disruptions. According to The International Disaster Database (2022), more than 14,600 disasters have occurred since 2000. These include but are not limited to droughts, earthquakes, epidemics, extreme temperatures, floods, industrial accidents, landslides, storms, transport accidents, volcanic activity, and wildfires. The top 100 disasters by the number of affected people were mainly caused by floods (44), droughts (30), and storms (23). In contrast, the top 100 disasters by the total adjusted cost of damages were primarily caused by storms (41), floods (28), and earthquakes (18). The costliest disasters between 2000 and when the database report was run were the Japan earthquake and resulting tsunami damaging the Fukushima powerplant in 2011, followed by Hurricane Katrina in 2005 and Harvey in 2017.

Shocks affecting global supply chains increase in frequency and severity. Disruptions lasting a month or more can occur almost every four years on average across industries, and shorter disruptions can happen even more frequently (Lund et al. 2020, chap. Section 1). Because of climate change, droughts, floods, storms, and other climatological, hydrological, and meteorological events will likely increase, leading to supply chain disturbances and disruptions. Already, extreme weather occupies the number one position in the short-term global top risk list and the number two position in the mid-term and long term risk lists. All the top five risks on the long term list are environment-related: climate action failure, extreme weather, biodiversity loss, natural resource crisis, and human environmental damage. (The Global Risk Report 2022, 25.) This aligns with the Intergovernmental Panel on Climate Change's (IPCC) report stating that there is an inevitable increase in climate hazards and related risks should global warming reach 1.5°C (IPCC 13, 2022). Because climate change is expected to increase the number of disruptions and disasters, organizations must adapt their supply chains accordingly (Nakano 2021, 10).

However, caution should be used with various forward-looking predictions. For example, infectious diseases occupied the last position on the global top risk list in

2019 and 2020, only to jump to the top in 2021 (The Global Risk Report 2019; 2020; 2021). The COVID-19 pandemic has impacted billions since it was declared a public health emergency of international concern in January and a pandemic in March 2020 by the World Health Organization (WHO). Many businesses, factories, and schools were closed during the following months. Supply chains were disrupted and people were forced to work or study from home or wear personal protective equipment. The impact of the pandemic is staggering. The WHO estimates that additional 15 million deaths were caused by COVID-19 between 2020 and 2021 (WHO 2022). The International Monetary Fund (IMF) predicts that by the end of 2024, the economic losses caused by COVID-19 will reach USD 13.8 trillion (IMF 2022).

In addition to the pandemic, the aftermath of Brexit, Evergreen containership blocking the Suez Canal, semiconductor shortage limiting the supply of goods with chips ranging from gaming consoles to cars, and the war in Ukraine are all examples of the growing pressure on global supply chains. In sum, the last three years have been exceedingly difficult, putting the resilience of individuals, organizations, societies, and supply chains to the test. One can only hope that these challenging times will act as a catalyst for building a more resilient future.

1.2 Research aims and questions

The main aims of this research are to understand and develop the case organization's supply chain resilience. The nature of supply chain resilience is examined with literature analysis. The empirical study is based on collecting data mostly with interviews and categorizing and analyzing data with Gioia, Corley & Hamilton (2013) method. There are three main research questions to support the research aims:

1. What does the concept of supply chain resilience mean for the case organization?
2. What factors influence supply chain resilience in the case organization?
3. How can the case organization develop its supply chain resilience?

The research aims and questions guide the selection of materials, interviewees, data collection, and data analysis. Although the thesis focuses on the case organization, it has the potential to help other organizations to develop their supply chain resilience.

1.3 Thesis structure

After the introduction, the second chapter introduces the case organization Nokia, its Mobile Networks business group, and its supply chain function, which is the focus of the thesis. The 3rd chapter defines the key terms and lays the theoretical foundation for the supply chain resilience study. The 4th chapter covers qualitative research, methodology, and data collection. The 5th chapter comprises research results, and the 6th and last chapter is dedicated to conclusions.

2 Case organization

2.1 Facts and figures

In 2021 Nokia's net sales were 22,202 million, gross profit was 8,834 million, operating profit was 2,158 million, and profit was 1,654 million Euros. The average number of employees working in 130 countries worldwide was 87,900. Over the past two decades, Nokia has invested more than 130 billion Euros in research and development. It has more than 4,000 essential 5G patent families, nine Nobel Prizes, and Ethisphere named Nokia one of the most ethical companies for the 5th time in 2021 (Nokia 2021a, 6-7.)

2.2 Purpose, strategy, and customers

Nokia's purpose is to create technology that helps the world act together. Its ambition is to build an inclusive workplace for its employees through open, fearless, and empowered principles. (Nokia 2021a, 4-5.)

Nokia's strategy consists of four strategic pillars. The 1st pillar, being a trusted partner, means engaging customers and understanding their needs and markets to create value. The 2nd pillar, technological leadership, is necessary to drive market share, have pricing power, and improve profitability. Only top-tier companies can earn high enough returns to survive in the competitive telecommunications industry. The 3rd pillar, capturing the value shift towards cloud and new business models, means focusing on software, services, and as-a-service models to increase flexibility and optimize cost and performance. The 4th and last strategic pillar, creating value with research and intellectual property, means innovating and investing in future technology, driving industry standardization, and capitalizing on intellectual property to ensure sustainable technological leadership and success. (Nokia 2021a, 18-19.)

Nokia has three main customer segments. The 1st segment, communications service providers or operators, offer data, voice, and other services to consumers, enterprises, and the public sector. The 2nd segment, enterprise verticals, are typically companies providing products and services for specific industries such as energy, manufacturing, and transportation that benefit from digitalization and automation. The 3rd segment, the so-called hyperscalers, are companies such as Alphabet, Amazon, Meta, and Microsoft, providing cloud-based services and solutions at a global scale. In addition to being customers, these are potential ecosystem partners and competitors. (Nokia 2021a, 14-15.)

2.3 Organization, products, and services

In addition to central functions, Nokia has four business groups that aspire to become market and technological leaders in their respective sectors. Mobile Networks (MN) business group supplies Nokia's customers with radio access networks related products and services and microwave radio links for transport networks. Network Infrastructure business group provides Nokia's customers with copper, fiber, fixed wireless access, data center, routing, and optical networks products and services. Cloud and Network Services business group supports Nokia's customers in monetizing 5G and deploying cloud-native software and as-a-service models. Finally, the Nokia Technologies business group manages the company's intellectual property, including the Nokia brand and patent portfolio. (Nokia 2021a, 8-9.)

The thesis focuses on the MN business group and its supply chain. In 2021, MN launched a new organization as part of Nokia's transformation program and a novel 5G product portfolio equipped with the latest system-on-chip technology, improving products' capacity and connectivity, thus increasing the product portfolio's competitiveness. MN's main competitors are Chinese Huawei and ZTE, Korean Samsung, and Swedish Ericsson. (Nokia 2021a, 26-28.)

2.4 Risk management and sustainability

Nokia's opportunity and risk management is based on a systematic approach covering compliance, financial, hazard, operational, and strategic opportunities, and risks. Those are identified, analyzed, managed, and monitored against strategy, objectives, and financials based on Nokia's enterprise risk management policy with the support of the risk management function and professionals. The key opportunities and risks that may impact Nokia's targets are reviewed by Nokia's leadership team and board of directors. Management assesses Nokia's internal controls over financial reporting annually following the Committee of Sponsoring

Organizations and Control Objectives for Information-Related Technology frameworks. (Nokia 2021a, 57.)

Regarding sustainability, Nokia sees the positive impact of technologies it develops, manufactures, and delivers to customers, i.e., handprint, mostly outweighing the adverse effects, i.e., footprint. Sustainability-related activities focus on three UN sustainable development goals. The decent work and economic growth goal relates to direct and indirect activities and economic impacts such as benefits, community investments, payments, purchases, and taxes. The climate action goal is the biggest challenge for businesses, the planet, and people. Nokia has set and committed to science-based targets that align with the 1.5ºC global warming scenario. The industry, innovation, and infrastructure goal is the most relevant goal because it is linked to the company's purpose to help the world act together. The products and services Nokia delivers provide organizations and people access to economic opportunities, information, and services. In addition, they provide industries enablers for sustainable growth and transformation through connectivity and digitalization. (Nokia 2021a, 94-96.) As Nokia's President and CEO, Pekka Lundmark, said: "*There's no green without digital. Nokia wants to lead the way on the global stage in making a case for digitalization as central to the climate challenge*." (Nokia 2021a, 13).

2.5 Supply chain and strategy

Nokia's supply chain comprises demand and supply planning, sourcing, manufacturing, and distribution. In 2021 Nokia purchased products and services from about 11,000 suppliers with more than 12 billion Euros and delivered products to customers despite the continued pandemic, worsening climate change, and geopolitical tensions. Nokia's leading approaches to increasing supply chain resilience include collaboration, digitalization, and partnerships. Nokia uses, e.g., artificial intelligence, machine learning, and simulation to optimize its supply chain and reduce disturbances and disruptions. A diverse supplier base and geographically distributed factories and electronics manufacturing service (EMS) partners help Nokia to reduce geographical and geopolitical risks. Nokia's and its EMS partners' factories are strategically located across the world. The geographical location and amount of manufacturing assets are as follows:

- Asia Pacific, India, and Japan (29 percent)
- China (29 percent)
- Europe (27 percent)
- the Americas (15 percent). (Nokia 2021a, 38-39.)

Although business groups' supply chains have much in common and there is collaboration across organizational boundaries, there are also differences in, e.g., processes, suppliers, systems, and tools. After the organization change in 2021, MN has its own Supply Chain and Strategic Sourcing organizations covering planning, sourcing, manufacturing, and distribution activities. In the previous organization, a centralized group function provided these as a service. Although much cannot be revealed about the current MN supply chain strategy for confidentiality reasons, it can be argued that it has a strong resilience focus. For example, a separate resilience and efficiency lever aims to improve business planning, delivery plan visibility, distribution network resiliency, supplier collaboration, and supply chain agility and flexibility. In addition, there are projects to increase digitalization through automation, control tower, and digital twin. Initiatives, such as regionalization and design for supply chain, will also positively impact supply chain resilience in the future. (MN Supply Chain Strategy 2022; Celebrating one year of our #MNSCstrategy 2022.) Supply chain resilience can be increased in the short term by buffering components and expediting logistics (MN COO All Hands 2022).

3 Theoretical background

3.1 Key terms and definitions

Definitions begin with basic dictionary definitions when available and progress towards more elaborate definitions found in literature and research articles. Definitions are listed in tables with references.

3.1.1 Supply chain

The thesis focuses on physical supply chains delivering tangible products to customers instead of service or digital supply chains. This is because physical supply chains are typically more vulnerable to disturbances and disruptions than service or digital supply chains and are therefore more interesting for study. However, material supply chains have service and digital dimensions, too. For example, payments and other transactions are conducted electronically. Table 1 provides selected supply chain definitions.

Definition	Source
"The system of people and things that are involved in getting a product from the place where it is made to the person who buys it."	Cambridge Dictionary (2022)
A supply chain is a sequence of events between the conception and consumption of products covering their entire lifecycle.	Blanchard (2010, 3)
A supply chain is a linear coordinated system that transcends organizational boundaries and is organized around material flows from sources of supply to customers.	Hsuan, Skjøtt-Larsen, Kinra, & Kotzab (2015, 15)
A supply chain is a network of suppliers, sub-suppliers, and service providers. It consists of materials used in production, materials suppliers, locations where materials and products are processed and distributed, inventories along the network, and the flow of information, materials, and money.	Sheffi (2015, chap. The Globalization of Supply Chains)
A supply chain comprises a plan, order, source, transform, fulfill, and return process modules. The plan module covers activities related to operating a supply chain considering its requirements, resources, and capabilities. The order module covers activities associated with customer purchases of goods and services and data such as order fulfillment, locations, and payment methods. The source module covers procuring, ordering, scheduling, delivery, receipt, and transfer of goods and services. The transform module covers activities associated with the scheduling and production of goods and services. The fulfill module covers activities related to order fulfillment, including scheduling, picking, packing, shipping, installing, commissioning, and invoicing orders. Lastly, the return module covers activities associated with reversing the flow of goods and services.	Association for Supply Chain Management (ASCM 2023)

Table 1: Selected supply chain definitions

Supply chains can be examined from different perspectives based on the above definitions. For example, it is possible to follow supply chains linearly or sequentially as raw materials are transformed into components and products

through value-adding processes. It is also possible to concentrate on supply chain information and monetary flows or study supply chains from a network or systems point of view. Critical supply chain drivers, e.g., supply chain costs, sustainability, and technology are not explicitly visible in the above definitions.

3.1.2 Resilience

Resilience is a multidisciplinary field of study, and no universally accepted definition exists. The term is often contextually defined. According to Shishodia, Sharma, Rajesh & Munim (2021, chap. 2 Literature review), there are nine different views on resilience concepts and application areas:

1. Ecological resilience: survival of ecosystems
2. Economic resilience: recessionary shocks
3. Engineering resilience: regain condition/form
4. Environmental resilience: adaptability of environments
5. Family resilience: avoid/survive family breakdowns
6. Psychological resilience: adaptability of people to circumstances
7. Social resilience: adaptability of social systems
8. Supply chain resilience: disruptions in demand/supply
9. System resilience: disturbances in systems.

The comprehensive list of resilience concepts and application areas above demonstrates that resilience covers much of the living and non-living world. Görner et al. (2022), in turn, talk about resilient growth and divide it into six categories:

1. Brand, reputation, environment, sustainability, and governance: communication and stakeholder management
2. Business model and innovation capability: customers, ecosystems, partnerships, and products
3. Digital and technology: analytics, automation, availability, cyber and information security, data protection, and quality
4. Financial: cash, cost, hedging, and pricing
5. Operational: maintenance, supply chain, and workforce
6. Organizational: decision-making, leadership, and talent.

The six resilient growth categories summarize resilience topics in a business environment. Table 2 presents selected definitions of resilience.

Definition	Source
"1: the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress 2: an ability to recover from or adjust easily to misfortune or change."	Merriam-Webster (2022)
Resilience is the ability to cope with high levels of challenge and maintain or regain high levels of effectiveness and well-being.	Hoopes (2017, chap. Introduction)
Resilience is the capacity of a system to cope with threatening events, disruptions, or trends by rearranging or responding to maintain function, identity, and structure while maintaining the ability to adapt, change and learn.	IPCC (2022, 7)
Resilience is the ability of communities, societies, and systems exposed to threats to absorb, accommodate, adapt, recover, resist, and transform the effects of risks efficiently and effectively by preserving and restoring vital functions and structures.	UNDDR (2022)
Resilience is an integrated approach to coping with disruptive events. It is the ability to adapt or rebound in the face of disruptions towards normal. Resilience can be recognized as a positive and proactive quality, but it can mean different things to different people and be applied differently in different situations.	Coaffee (2019, 13)

Table 2: Selected resilience definitions

Based on the above definitions, resilience can be viewed as an ability, capability, capacity, or process to deal with disturbances or disruptions while maintaining function. Resilience has proactive, concurrent, and reactive dimensions or a temporal aspect. It seems a versatile yet elusive concept that may be challenging to quantify and measure.

According to Coaffee (2019, 13-14), the traditional view of resilience as bouncing back or maintaining the status quo is challenged by a novel idea of resilience as jumping forward to a new normal. This change is driven by increased complexity, interconnectivity, and insecurity. Coaffee (2019, 51-53) continues that resilience is

no longer seen as a balancing act but as a process for adaptation, growth, self-regulation, and transformation. Disturbances and disruptions are perceived as external threats and outcomes of historical, organizational, or societal processes. In other words, resilience is more about working with uncertainty than controlling or defending against it. Nieminen et al. (2017, 10) share a similar view and state that the idea of bouncing back is no longer valid because change is constant, and it may not even be possible to return to the same condition that was before a disturbance or disruption. Also, when defining resilience, it is imperative to specify whether it is viewed as a characteristic, outcome, or process (Southwick, Bonanno, Masten, Panter-Brick & Yehuda 2014, 2).

3.1.3 Supply chain resilience

Systematic literature reviews cover various supply chain resilience-related research subjects, theories, and methodologies. Based on reviews, common supply chain resilience research subjects include business, management and accounting, computer science, economics, engineering, and environmental and social science (Agrawal & Jain 2021; Suryawanshi & Dutta 2021). Furthermore, common supply chain resilience research theories include complex adaptive systems, complexity, contingency, dynamic capabilities, graph, relational, and resource-based view theories (Agrawal & Jain 2021; Kochan & Nowicki 2018; Shishodia et al. 2021). Widely used supply chain resilience research methodologies include case studies, conceptual and theoretical methods, literature reviews, modeling and simulation, and surveys (Ali, Mahfouz & Arisha 2017; Kochan & Nowicki 2018). Supply chain resilience is the essential term of the thesis and builds on the previous definitions of supply chain and resilience. Table 3 lists selected supply chain resilience definitions.

Definition	Source
Supply chain resilience is the ability of a supply chain to prepare for unexpected disruptive events, respond and recover quickly and return to the original or more desirable state.	Hohenstein, Feisel, Hartmann & Giunipero (2015, 90)
Supply chain resilience is the supply chain's adaptive capability to prepare for the unexpected, respond, and recover by sustaining operations and controlling function and structure.	Ponomarov & Holcomb (2009, 131)
Supply chain resilience is a dynamic process to help organizations avoid disruptions. Should disruptions occur, organizations can respond quickly and efficiently to minimize impact, maintain or recover operations and adapt to new circumstances ahead of the competition.	Datta (2017, 1393)
Supply chain resilience is the ability to plan and design a supply chain network in anticipation of unexpected events, respond adaptively, maintain control, and return to a more favorable state of operations, if possible, to gain a competitive advantage.	Ponis & Koronis (2012, 925-926)
Supply chain resilience is the adaptive capacity of organizations in changing and complex environments. Supply chains can prevent, resist, and return to acceptable performance levels within a sufficient time after being affected by disturbances or disruptions. Supply chain resilience is also the capability to maintain function and structure upon internal or external changes and degrade gracefully when necessary. In addition, it is a comprehensive and systematic process of prevention, protection, preparedness, mitigation, response, continuity, and recovery.	SFS-ISO 28002 (2011, v-8)

Table 3: Selected supply chain resilience definitions

Based on the above definitions, supply chain resilience can be examined from ability, capability, capacity, or process points of view like resilience. The traditional bouncing-back interpretation is visible in definitions. However, there is a notion that supply chains may not fully recover and the situation after a disturbance or disruption differs from the previous, hence references to new circumstances, acceptable levels, and degradation with grace. Temporal references cover supply chain disruptions' before, during, and after stages. The references to unexpected

events suggest that organizations should not only focus on existing and known risks but also prepare for known unknowns and unknown unknowns. The terms known knows, known unknowns, and unknown unknowns are attributed to the late US Defense Secretary Donald Rumsfeld. According to Rumsfeld, there are known knowns, i.e., things we know we know. There are also known unknowns, i.e., things we know we do not know. Lastly, there are unknown unknowns, i.e., things we do not even know that we do not know. (Zak, 2021.) Definitions' references to competition and competitive advantage should put supply chain resilience to every leader's focus because it is a vital strategic element.

The above definitions assume that the readers already understand what supply chain means. Because this may not always be the case, the thesis author offers the following supply chain resilience definition to the discussion.

Supply chain resilience is the ability of a complex adaptive system that provides customers with goods and services through the plan, order, source, transform, fulfill, and return processes to continue operations at acceptable times and levels despite unexpected internal or external disturbances or disruptions. Supply chain resilience starts with an assumption that not all events can be avoided and seeks to adapt, learn, and thrive in new circumstances, if possible. The supply chain is fortified by prevention, protection, preparedness, mitigation, response, continuity, and recovery processes, bridging temporal aspects of disturbances and disruptions.

This definition is based on the earlier supply chain resilience definitions but focuses more on the supply chain and processes. Diverse definitions help to understand constructs from different perspectives. Sometimes it may be helpful to break definitions into their constituent parts and put those back together again to see whether something new can be learned. This is done in Chapter 5.1. when defining a new supply chain resilience definition for the case organization.

3.1.4 Resilience and risk

It may be difficult to distinguish between resilience and risk in daily discussions. Risk is defined as uncertainty's effect on an organization's aims and objectives. The effect is a deviation from what was expected, and it can be harmful, positive, or both resulting in possible threats and opportunities. Risk is typically articulated regarding consequences, events, likelihoods, and risk sources. Risk management consists of the organization's coordinated efforts to control and direct risk. (SFS-ISO 31000 2018, 1.) The core of the risk management process consists of setting the scope, context, and criteria, performing risk assessment including risk identification, risk analysis, and evaluation, followed by selecting, executing, and

monitoring risk mitigation actions such as risk avoidance, removal of risk sources, changing risk likelihood and consequence and sharing risk (SFS-ISO 31000 2018, 10-13.)

Uncertainty is also associated with resilience, which is a different but affiliated concept. Risk is typically more technically oriented and focuses on controls, likelihoods, and specific system parts. In contrast, resilience focuses more on the entire system, relationships between its features, and organizational and social factors. (Coaffee 2019, 45-46.) Instead of toughening parts of the system against specific threats, resilience prepares the system against various threats that can lead to disruptions (Linkov & Trump 2019, 2). Risk management practices trying to control uncertainty through impact and likelihood assessments and related mitigation actions are typically short-term focused, reactive, and based on historical data, making them unfit for an increasingly unpredictable world (Coaffee 2019, 6). Today's world is plagued by complex disturbances and disruptions with different origins and long-lasting consequences. The COVID-19 pandemic is a case in point. It started as a public health concern but quickly became an economic, organizational, and social crisis. Organizations cannot afford anymore to react separately to each disruption, and their risk management practices must match the current challenges. (Brende & Sternfels 2022.)

Resilience tends to focus on the unknown and unexpected high-impact and low-likelihood events often neglected by traditional risk management (Coaffee 2019, 104). According to Pournader, Rotaru, Kach & Razavi Hajiagha (2016, 603), the rare high-impact and low-probability events are the ones threatening supply chains the most, and the lack of historical data leaves performing simulations with synthetic information or using expert knowledge for extrapolating the effects as only plausible risk management options. Simchi-Levi, Schmidt & Wei (2014) share a similar view and conclude that because historical data on rare occasions is limited and related risks are difficult to quantify, many organizations are not adequately prepared. Instead of guessing the likelihood of rare events, organizations should concentrate on identifying and evaluating their vulnerabilities to disruptions regardless of the causes or places they might happen. Traditional risk management is not well equipped to cope with unforeseeable events, so supply chain resilience is needed to fill the gaps (Pettit, Fiksel, & Croxton (2010, 5). Most importantly, resilience starts with a realization that all events cannot be prevented (Coaffee 2019, 64).

3.2 Building blocks of supply chain resilience

3.2.1 Fundamentals

Supply chains can be viewed as complex adaptive systems (Pournader et al. 2016, 589). Complex adaptive systems cannot be well defined and understood by investigating their constituent parts alone. This is because systems' parts interact with each other and their environments, producing complex behaviors. Characteristically, complex adaptive systems have many features with one or several levels of feedback. They demonstrate emergent properties and self-organization capabilities and produce dynamic non-linear behaviors. Therefore, complex adaptive systems need to be studied holistically, considering the constituent parts and their relationships. (Carmichael & Hadzikadic 2019, 2.) The same applies to supply chain resilience.

Because of the complex nature of supply chain resilience, researchers approach the topic from diverse perspectives. In addition, there is already a vast amount of supply chain resilience research subjecting it to systematic literature reviews. An analysis by Hohenstein et al. (2015, 99-101) reveals that supply chain resilience definitions typically cover four phases, i.e., response, recovery, growth, and readiness. The same analysis lists the most studied supply chain resilience elements, i.e., agility, capacity, collaboration, culture, flexibility, information sharing, inventory, multiple sourcing, redundancy, and visibility. Analysis by Spieske & Birkel (2021, 8) produces another list of the most studied supply chain resilience factors, i.e., collaboration, sourcing, supply chain design, supply chain risk management culture, supply chain understanding, velocity, and visibility. Agarwal, Seth & Agarwal (2022, 749-750) identify 16 supply chain resilience enablers and categorize those under three groups. The strategic enabler category includes decision-making, real-time information, collaborative forecasting, local backup suppliers, information tracking mechanisms, business intelligence mechanisms, information sharing mechanisms, and reserve capacity. The tactical enabler category includes proactive identification, quick action, joint operations, and a multi-skilled workforce. The operational enablers category includes production, contract, sourcing, distribution, and logistics flexibility. Based on an earlier literature review, authors Agarwal, Seth & Agarwal (2020, 100) list 15 characteristics of resilient supply chains. These are adaptation, agility, built-in interoperability/process integration, collaboration, flexibility, information sharing, redundancy, resource configuration, risk management culture, robustness, social capital, supply chain redesign, top management support, velocity, and visibility.

Regarding strategies that help organizations mitigate supply chain disruptions, Agrawal & Jain (2021, 2515) identify 14 strategies that constitute a supply chain resilience framework against disturbances and disruptions due to customer, external, internal, or supply issues. These strategies are adaptive capacity, agility, ambidexterity, collaboration, data analytics, flexibility, information sharing, integration, recovery, redundancy, responsiveness, supply chain readiness, trust, and velocity. Shishodia et al. (2021, chap. 3.1 Selection of database) categorize supply chain disruption mitigation strategies under pre-disruption, during disruption, and post-disruption phases in their bibliographic analysis. These phases contain different strategies, but all include information sharing and visibility. Tukamuhabwa, Stevenson, Busby & Zorzini (2015, 5601-5603) cluster supply chain disruption mitigation strategies under proactive and reactive phases. The phases share five common strategies, i.e., information technology, logistics capabilities, social capital and relational competencies, supply chain collaboration, and visibility.

The most comprehensive systematic literature review identified during the thesis study covers 103 peer-reviewed supply chain resilience-related journal articles between 2000 and 2015. It identifies five supply chain resilience capabilities, 13 essential elements, and 84 managerial practices that build a complete supply chain resilience framework (Ali et al. 2017, 16). The framework is presented in Appendix 1. Interestingly, innovation and sustainability are not visible in the framework, although both are found in the review's complete list of identified elements (Ali et al. 2017, 38-39). Golgeci & Ponomarov (2013, 604) study innovation and its relationship to supply chain resilience and find that innovation is positively associated with supply chain resilience. López-Castro & Solano-Charris (2021, chap. Abstract) state that supply chains must respond to economic, environmental, social, and uncertainty-related considerations. Therefore, organizations must incorporate sustainability and resilience into supply chain design. However, according to Rajesh (2021, chap. Abstract), contradictory sustainability and resilience principles force organizations to make trade-offs between them. One example of such a trade-off is related to an efficiency gain through waste reduction, a sustainability principle, which reduces available buffers in the supply chain and decreases flexibility, a resilience principle, at the same time (Rajesh 2021, chap. 2.1. Focus on efficiency/focus on flexibility).

The supply chain resilience fundamentals discussed above share many similarities but also differences. The differences may result in part from the terminology. Kochan & Nowicki (2018, 847) and Han, Chong & Li (2020, 4546) find supply chain resilience terminology inconsistencies based on their literature reviews. Supply chain resilience researchers need a greater consensus about the terms so that the

concept and literature can develop systematically (Hohenstein et al. 2015, 102). Other possible factors explaining the terminology differences include research focus, scope, and the time literary reviews were conducted. Selected elements of supply chain resilience often appearing in the research literature are discussed next.

3.2.2 Financial assets and performance

Supply chain disturbances and disruptions can harm organizations' financial performance. For example, sudden demand or supply changes can influence organizations' cash flows, costs, inventories, and margins. In addition, there may be concerns about supporting suppliers in situations when members of the supply chains depend on others to maintain operations during crises. (Pimenta et al. 2022, 653.) Therefore, building resilience and optimizing financial assets is crucial before, during, and after disturbances and disruptions. This is evidenced by the financial crisis between 2007 and 2009. During that time, resilient companies created about 20 percent more shareholder returns than non-resilient companies, followed by about 50 percent between 2009 and 2011 and 120 percent between 2011 and 2017. Financial strength, i.e., cash reserves, flexible cost base, profitability, and business model adaptation through divestments and reinvestments, emerged as a crucial element of resilience. (Brende & Sternfels 2022, chap. 2.1 Business resilience.)

Supply chain resilience positively impacts organizations' financial performance (Li, Wu, Holsapple & Goldsby 2017, 254). This is probably one of the main reasons why organizations engage in supply chain resilience-related activities in the 1st place. Lund et al. (2020, chap. Section 3) investigate two long-lasting and severe supply chain disruptions scenarios and find that a single continued production disruption could erase 30 to 50 percent of one year's EBITDA in most industries. According to a 2020 survey of supply chain executives, 93 percent reported planning to invest in supply chain resilience, including building redundancy, nearshoring, unique part reduction, and regionalization (Lund et al. 2020, chap. Section 5). However, organizations should balance between investing in supply chain resilience capabilities that enable organizations to anticipate and overcome disturbances and disruptions but reduce profits, and vulnerabilities that make organizations prone to troubles and expose them to risks (Pettit et al. 2010, 7). The concept of balanced resilience is visualized in Figure 1.

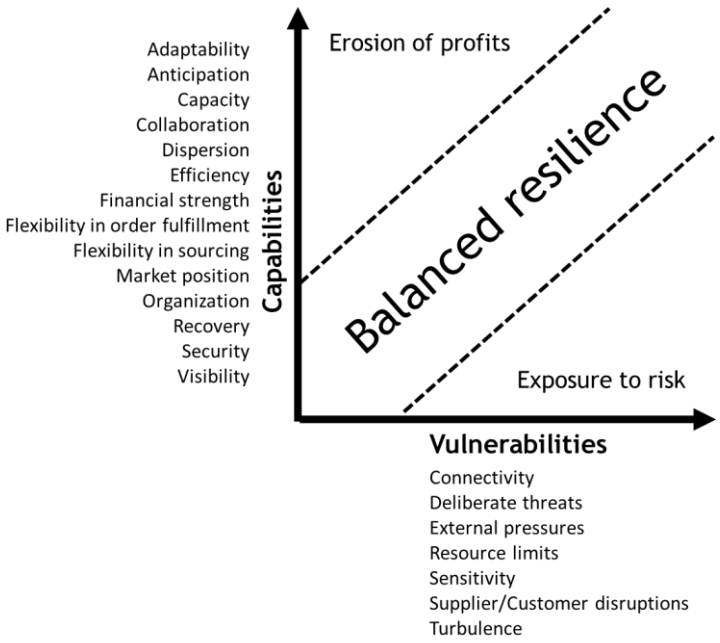

Figure 1: Concept of balanced resilience and related capability and vulnerability factors (modified from Pettit et al. 2010, 8 and 11-12)

Based on Figure 1, supply chain resilience increases as its capabilities increase and/or vulnerabilities decrease. However, excessive abilities increase costs, and extreme vulnerabilities increase risks (Pettit et al. 2010, 6-7). This leaves organizations with three basic options for managing supply chain resilience: increasing capabilities, decreasing vulnerabilities, or both.

3.2.3 Measurement

In addition to understanding supply chain resilience fundamentals, it is also crucial for organizations to know how to measure supply chain resilience. This may be challenging, however, because there is no one right approach to measuring supply chain resilience. According to Pettit et al. (2010, 7), organizations can evaluate their current resilience levels and make development plans by measuring supply chains' capabilities and vulnerabilities. Bret, Dussud, Metral, Ladier & Trilling (2021, 17-18) argue that it is challenging for organizations to measure supply chain resilience with one reliable indicator. Instead, the authors propose a methodology for supply chain mitigation scenario assessment consisting of five steps, the last of which is measurement. Pournader et al. (2016, 604) trust in collaboration between supply chain stakeholders in supply chain resilience measurement and conclude that organizations should adopt both a system-wide and tier-specific approach to measurement because a realistic measurement can only be achieved through a coordinated effort of all supply chain participants. Han et al. (2020, 4550) suggest a

more targeted approach according to which organizations should establish separate measures for agility, collaboration, contingency planning, flexibility, market position, redundancy, situational awareness, and visibility. Taking the market position as an example, they (ibid.) suggest that organizations follow customer satisfaction, financial performance, and damage from disruption.

Organizations requiring more detailed supply chain measurement approaches have options. For example, Dixit, Verma, & Tiwari (2020, chap. 6. Conclusion) study supply chain resilience based on network structural parameters and conclude that resilience can be computed as the compound effect of supply chain centrality, connectivity, density, and network size. Organizations can understand supply chains' worst-case scenario performance using a simulation-based approach and computing the conditional value-at-risk (CVaR) when networks are subjected to high-impact and low-probability disruptions. Sawik (2011, 194-195) studies the optimal selection of supply portfolio in a make-to-order production environment and proposes a portfolio approach to measurement, making it possible to apply popular risk measures of CVaR and the value-at-risk (VaR) to supply chain disruptions. The CVaR enables organizations to evaluate worst-case supply chain disruption costs and modify the cost distribution via optimal supplier selection and order allocation decisions. The CVaR is used with the VaR to estimate the risk with non-symmetric cost distributions. Simchi-Levi et al. (2014) develop a mathematical linear optimization model to determine the optimal response to supply chain node disruption for the duration of its total time of recovery (TTR), i.e., the time it takes for a node to recover from a disruption. The model can calculate a risk exposure index for each supply chain node, and scores enable organizations' supply chain professionals to identify nodes deserving of attention. Another metric, i.e., the total time to survive (TTS), is inspired by the TTR. The TTS can be used as a resilience measure when the supply chain disruption's length is unknown. The TTS is the longest-time customer service level that can be guaranteed if a supply chain facility is disrupted. If TTS is greater than TTR, then a disruption in that facility does not impact the organization's service level. Respectively, disruption affects service when a facility's TTS is shorter than TTR. (Simchi-Levi, Wang & Wei 2018, chap. 5.1. Time-to-Survive Model.) Behzadi, O'Sullivan & Lennon Olsen (2020, 150-157) present a new supply chain resilience metric, i.e., the net present value of the loss of profit (NPV-LP), incorporating many aspects of other resilience metrics, i.e., TTR, the recovery level (RL) and the lost performance during recovery (LPR). NPV-LP is a combined metric integrating many aspects of resilience to model the elaborate concept of supply chain resilience.

In addition to applying different supply chain resilience measures, organizations can adopt a tool-based approach to supply chain resilience measurement. Pettit, Croxton & Fiksel (2013, 46) developed Supply Chain Resilience Assessment and Management (SCRAM) tool based on the crucial linkages between the supply chain capability and vulnerability factors. Using mix-methods triangulation, authors identify over 300 connections that can be used to guide organizations' supply chain resilience development. The same 21 supply chain capability and vulnerability factors at the core of the SCRAM tool are also visible in Figure 1. Interestingly, there seems to be little research on using the supply chain resilience maturity models for supply chain resilience measurement and development purposes.

3.2.4 Digitalization and technology

In supply chain resilience discussions, automation, digitalization, and technology arise often. According to the systematic literature review by Spieske & Birkel (2021, 7), big data analytics has the most significant absolute and relative share of the Industry 4.0 supply chain resilience enabler technology references, followed by the internet of things, artificial intelligence, blockchain, cloud computing, additive manufacturing, and cyber-physical systems. Although Industry 4.0 eludes definitions the same way supply chain resilience does, it can be referred to as an autonomous smart manufacturing networking concept (Ivanov, Dolgui & Sokolov 2019, 831). Zouari, Ruel & Viale (2021, 149-154) study 15 digital technologies impacting supply chains. Those technologies are advanced human-technology interfaces, advanced manufacturing, artificial intelligence, augmented/virtual reality, big data analysis, blockchain, cloud computing, collaborative technologies, internet of things, location technologies, machine learning, mobile devices/wearables, robotic process automation, self-driving vehicles, and smart sensors. They (ibid.) conclude that supply chain digitalization is influenced by organizations' digital maturity and adoption of digital tools, which positively impact organizations' supply chain resilience. However, when considering applying these technologies to develop supply chain resilience, organizations should remember that technology is only effective when used within the proper contexts in the organization (Faruquee, Paulraj & Irawan 2021, 1192).

Frederico, Kumar, Garza-Reyes, Kumar & Agrawal (2021, chap. Abstract) study technology's impact on supply chain performance and resilience. They (ibid.) find that Industry 4.0 technologies significantly influence supply chain performance regarding collaboration, integration, responsiveness, and transparency. However, the findings do not support the view that these technologies improve supply chains' efficiency, which contrasts with the existing literature. The results show that

integrating Industry 4.0 technologies positively impacts supply chain processes' profitability. Organizations' supply chain risk information processing capabilities, such as supply chain risk information analysis and sharing, significantly affect supply chain finance and resilience (Yuan & Li 2022, chap. Abstract).

Supply chain disruptions caused by COVID-19 and post-pandemic recovery suggest an urgent need for digital twins, i.e., computerized models representing supply chain network states, for mapping supply chain networks and ensuring supply chain visibility (Ivanov & Dolgui (2021, 775). Digital twins can be used proactively to evaluate disruptions' impact on supply chains' performance and optimize recovery models. For example, data analytics can build disruption scenarios based on historical and other data during supply chain design. Data analytics can also be used reactively for real-time disruption identification using data from RFID, sensors, and track and trace systems. In addition, digital twins' data analytics enable integrating monitoring and observation functions to supply chain disruption management. (Ivanov & Dolgui (2021, 780.) The authors create a generalized digital twin framework for supply chain disruption management. The framework is described in Figure 2.

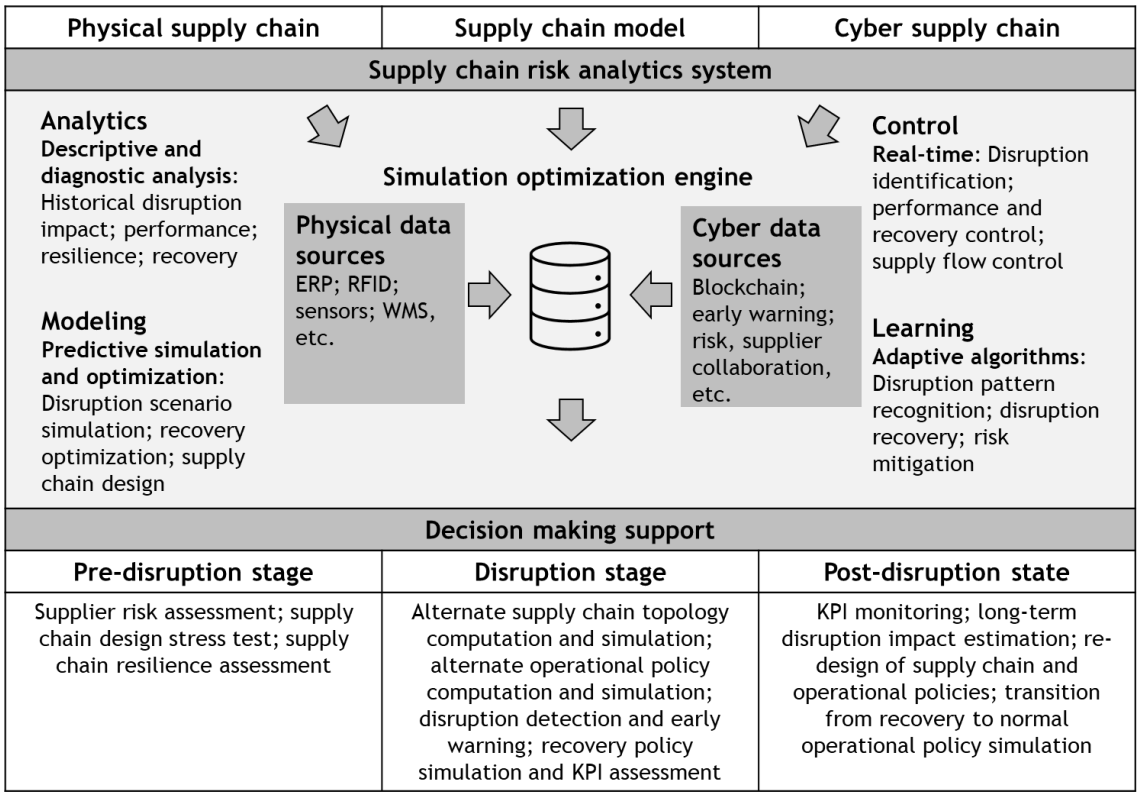

Figure 2: Digital twin framework for supply chain disruption management (modified from Ivanov & Dolgui 2021, 783)

As depicted in Figure 2, the digital twin framework can be seen as a cyber-physical system integrating both physical processes and virtual computational services. The computerized supply chain model representing the current state of supply chain networks can be used by artificial intelligence algorithms in cyberspace and supply chain professionals in physical space. In addition, digital twins enable organizations to experiment with what-if scenarios, understand the effects of changes, and consider options. Therefore, digital twins increase organizations' supply chain resilience through fast and reliable recognition of supply chain disturbances and disruptions and avoidance of their negative consequences (Ivanov & Dolgui 2021, 782-783.) As organizations start to connect digital twins, this can lead to the enterprise metaverse (McKinsey & Co, 2022).

3.2.5 Transparency and visibility

Supply chain transparency and visibility are crucial for supply chain resilience. Montecchi, Plangger & West (2021, 1-11) conduct a bibliometric review on supply chain transparency and identify six relevant literature subdomains: governance, knowledge integration, resilience, sustainability, transparency technologies, and traceability. Authors find that supply chain transparency is a critical organizational capability enabling the construction of information links between organizations and their internal and external stakeholders. Increasing supply chain transparency is an internal governance system and reduces organizations' operational risks. In addition, organizations' visibility of upstream and downstream processes leads to increased accountability and control of supply chain operations. Greater transparency reduces stakeholders' uncertainty and promotes a collaborative and open culture. In addition, improved supply chain transparency provides assurances of products' authenticity, a chain of custody, integrity, and origin. It reduces information asymmetry between sellers and buyers, reduces market transaction risks, and creates stakeholder trust. Supply chain transparency empowers stakeholders to assess organizations' commitments toward environmental, social, and sustainability goals.

Another review by Kalaiarasan, Olhager, Agrawal & Wiktorsson (2022, 1) finds that supply chain visibility literature perspectives can be clustered into four categories: antecedents, barriers and challenges, drivers, and effects, or ABCDE in short. Based on these categories, the authors propose the ABCDE supply chain visibility framework, presented in Figure 3.

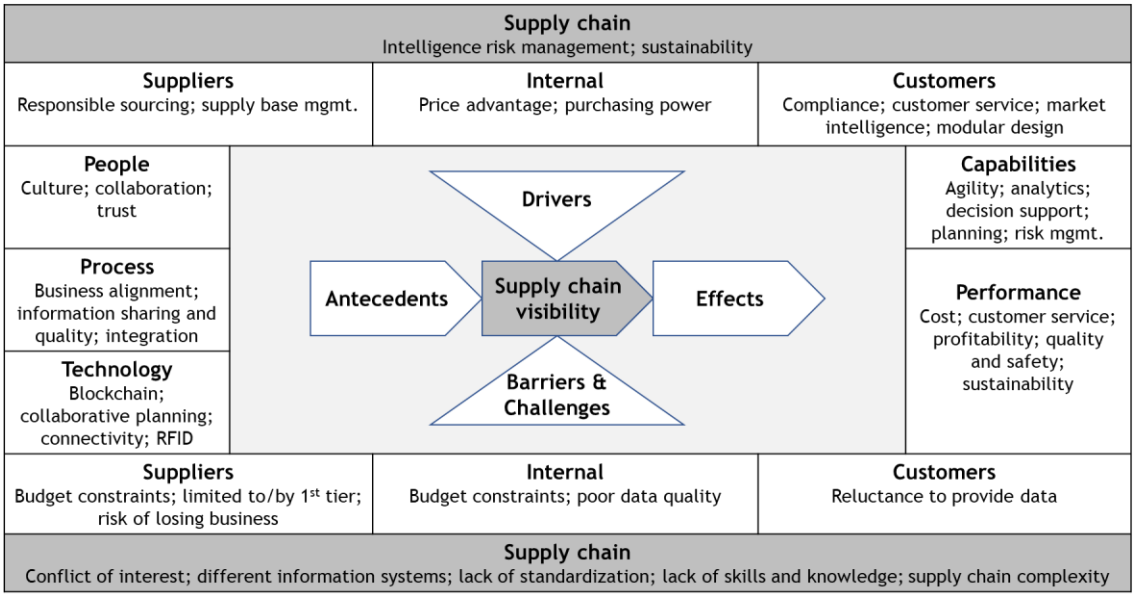

Figure 3: The ABCDE supply chain visibility framework (modified from Kalaiarasan et al. 2022, 8)

The ABCDE supply chain visibility framework presents a holistic view of supply chain visibility, and it can be used by supply chain professionals to identify and discuss factors that are important for organizations to improve visibility. Because of its many dimensions, the supply chain visibility framework may seem challenging to implement. (Kalaiarasan et al. 2022, 8). However, it can be argued that visibility and transparency are critical prerequisites for supply chain resilience. With visibility and transparency, organizations know what happens before, during, and after supply chain disturbances and disruptions. This is probably why organizations invest in automation, digitalization, measurement, and technology; to have better situational awareness and make better decisions.

3.2.6 Collaboration

Because of the systemic nature of supply chains, collaboration between stakeholders is essential. Organizations must change their approach from siloed to inclusive. Top management commitment is a starting point for a collaborative resilience journey and is one of the most critical factors for building collaborative resilience in organizations. Collaborative culture and designing resilience into operations positively affect supply chain resilience. Furthermore, joint resilience goal alignment between supply chain stakeholders and adaptation after disturbances and disruptions is essential in building collaborative strength across supply chains. However, organizations must build supply chain resilience individually before making

collaborative efforts and investments with supply chain partners. (Aggarwal & Srivastava 2019, 1426-1427.)

Scholten & Schilder (2015, 471) study collaboration's influence on supply chain resilience and find that collaborative communication, information sharing, mutual relationship efforts, and mutual knowledge creation improve supply chain resilience through increased flexibility, velocity, and visibility. In addition, the authors find that sharing information soonest possible is essential to ensure quick responses to supply chain disturbances and disruptions. Although counterintuitive, collaborating with competitors during disruptions can increase supply chain resilience by adding flexibility. The longer organizations have worked together, the more resilient they are against disturbances and disruptions because of the increased velocity and visibility. (Scholten & Schilder 2015, 482.) This suggests that building and nurturing long-lasting business relationships is beneficial for organizations from a supply chain resilience point of view. Fayezi & Ghaderi (2022, 159) study mechanisms via which inter-organizational relationships contribute to supply chain resilience and find that collectivity, connectivity, and scalability are vital mechanisms via which cross-organizational relationships contribute to supply chain resilience.

3.2.7 Competencies and learning

Mandal (2017, 190) studies the influence of supply and demand competencies on organizations' supply chain resilience and performance. Supply competencies refer to production and supply management-related competencies, and demand competencies refer to distribution and demand management-related competencies. Mandal (ibid.) finds a positive relationship between supply and demand competencies and organizations' supply chain resilience and performance. Mubarik, Bontis, Mubarik & Mahmood (2022, 713) study intellectual capital's influence on supply chain resilience in organizations. They (ibid.) find that intellectual capital categorized by human, relational, and structural capital significantly influences organizations' supply chain learning and resilience. Also, an organizational comparison demonstrates that organizations with higher levels of intellectual capital perform better than those with lower levels of intellectual capital.

Scholten, Sharkey Scott & Fynes (2019, 430-438) discover six learning mechanisms and related antecedents that promote supply chain resilience through organizational knowledge creation and transfer across the supply chains. Processual learning is proactive knowledge creation in response to organizational, operational, growth, and strategy changes. Anticipative learning, as the name implies, occurs purposefully in anticipation of possible supply chain disturbances and disruptions

through specific training and collaboration with supply chain partners and other industries. Situational learning occurs during the supply chain disruption response phase when gaps in organizational routines become visible. Collaborative learning, which is unintentional, occurs during the supply chain disruption phase when there are no contingency plans, for example, requiring immediate response from the stakeholders. Experimental learning happens in the recovery phase through formalized reviews. Lastly, vicarious learning is based on organizations' attempts to address the shortcomings in collaboration and information sharing that led to supply chain disturbances or disruptions in the 1st place.

According to The Business Continuity Institute (Continuity and Resilience Report 2022, 35-36), soft skills are the most desirable attributes of contemporary business continuity professionals. The top five attributes are communicator, relationship builder, good planner, problem solver, and collaborator. In contrast, the bottom five are giving orders, controlling, being risk averse, risk-taking, and having a high level of academic qualification. This aligns with the perception that business continuity and resilience are considered strategic and integrated disciplines instead of standalone functions requiring a specific skill set.

4 Qualitative research

4.1 Methodology

The qualitative methodology generally refers to research producing descriptive data based on words and behaviors. Qualitative researchers are typically interested in how people think and act and what meaning they assign to their lives and events. Qualitative research is inductive, meaning researchers develop concepts, perceptions, and views from data patterns instead of collecting data to validate hypotheses, models, or theories. Qualitative research is as much a science as an art because it is less standardized than other research types. (Taylor, Bogdan & DeVault 2015, 17-21.)

Qualitative research allows students to explore various topics because it is less constrained by data series, experiment conditions, and sample sizes, making it a popular approach in academic and professional fields. In addition, qualitative research offers several research variants for researchers to choose from and favors collecting, integrating, and presenting a wide variety of data from many sources. (Yin 2015, 6-11.) However, some research may employ only one data collection

method, while others incorporate multiple forms such as interviews, participant observations, and written surveys (Saldana 2011, 31).

In qualitative research, collecting and analyzing data are overlapping processes (Saldana 2011, 95). Interviews are understood as an interaction where the role of the interviewer in shaping the material cannot be eliminated. Qualitative research values natural and unstructured data and focuses typically on what and how questions. Agency, perspective, the subjectivity of individuals, and the shared meaning of groups are appreciated. This also means that researched topics are only sometimes easily analyzed and presented because of a lack of transparent cause-and-effect relationships and conflicts. (Juhila 2022.)

Qualitative research has been criticized for lacking credible interpretations of data and scientific rigor. One way to improve scientific rigor is to organize the collected data into 1st and 2nd-order categories. The 1st-order analysis adhering closely to interviewees' direct input and terminology typically leads to a wide variety of categories. However, as the research progresses, similarities and differences among the classes emerge, and the number of categories becomes more manageable. The 2nd-order of analysis produces emerging themes helping to explain the research subject in more detail, after which aggregate-level concepts might appear, providing even a higher level of abstraction. (Gioia, Corley & Hamilton 2013, 15-21.) This data analysis approach is the Gioia method and is applied in the thesis.

Another research design decision applied in the thesis relates to selecting a qualitative research variant, i.e., a case study. Simons (2009, 18) defines a case study as a process of conducting a systematic and critical investigation into a research subject and generating understanding that contributes to the public knowledge of the subject. According to Saldana (2011, 8-9), a case study focuses on a single item for analysis, and the purpose is not necessarily to develop argumentation for general applicability or representation. A case can be chosen deliberately for its unique characteristics, strategically representing a larger group, or simply for convenience. Although all these reasons are applicable in the context of the thesis, the convenience reason stands out because the thesis author has intimate knowledge of the case organization through employment and has access to relevant informants and materials. According to Simons (2009, 23-24), case studies are especially suitable for exploring multiple perspectives, telling stories of programs and policies in action, and understanding change. Concerns about using case studies include, e.g., personal involvement and subjectivity.

Reliability and validity refer to the accuracy and replicability of measures necessary in quantitative research, but credibility and trustworthiness are more relevant concepts in qualitative research. Credibility is the unity of the thesis, explaining and convincing the readers that the thesis author had it methodologically correct. Credibility can be established, e.g., by citing relevant authors and papers in the text and bibliography, specifying applied data collection and analytics methods, or by data triangulation describing different materials collected and used to offer multiple perspectives. Trustworthiness, in turn, can be referred to as providing credibility to the thesis by informing readers about the research process in general. This can be done, e.g., by stating the duration of research, the amount of data gathered, or research challenges encountered during the research process. In sum, credibility and trustworthiness are about researchers' honesty and integrity. (Saldana 2011, 134-136.)

Regarding research paradigms, most qualitative researchers adopt a postmodernist view of epistemology, suggesting there is no absolute truth. Instead, knowledge is constructed within individuals and groups, depending on context and settings. (Saldana 2011, 22-23.) The thesis author holds the same view. Similarly, a constructionist perspective is relevant to the thesis. It means that reality is understood as being constantly constructed via action and speech, and the focus is on activities, collaboration, and culture (Jokinen 2022).

4.2 Data collection

According to Saldana (2011, 33), researchers must determine the appropriate informants most likely to produce research-relevant answers during interviews. A total of 20 interviews were conducted between June 10th and October 24th, 2022. The informant selection was based on the following:

- Supply Chain Head's recommendation
- Sourcing or supply chain experience
- Engagement in annual or strategic planning
- Leadership position
- Gender and geography.

The thesis author's network built during a 20-year career in the company helped in identifying and engaging relevant informants. The informant statistics are summarized in Table 4.

Attributes	Figures
Gender	Female (9/20), male (11/20)
Geography	China (1/20), Europe (10/20), North America (4/20), India (2/20), Asia Pacific and Japan (1/20), Latin America (1/20), Middle East and Africa (1/20)
Leadership position (member of unit's leadership team)	9/20
Leadership position (people manager)	19/20
Organizational breakdown (high level)	Supply Chain (15/20), Strategic Sourcing (4/20), Environment Social and Governance (1/20)

Table 4: Interviewee statistics

The gender split of informants was almost balanced. Most informants were based in Europe, so there is a potential geographical bias. However, efforts were made to include informants from other markets. Most informants came from the Supply Chain organization, so here is another potential source of bias. All informants are engaged in annual or strategic planning, are in leadership positions, and act as people managers and/or members of the Supply Chain or Strategic Sourcing leadership teams. Based on the common working history the thesis author has with the respondents and the requirements of their positions, it can be concluded that informants have an extensive experience in sourcing and/or supply chain. Two informants left the company before the thesis project was completed.

Invites for 30-minute interviews were sent to the selected candidates via email. The invites summarized essential topics such as purpose and privacy. Audio and video recordings were downloaded and stored in the mp4 file format, and live transcripts were downloaded and stored in the docx-file format on the thesis author's OneDrive. The 1st four interviews were conducted using both Teams' audio and video. However, a chance event led to a realization that although the video was good for creating and maintaining a connection with the informants, it slowed down the pace of conversations. Therefore, the remaining 16 interviews were conducted with audio to ensure sufficient time for discussions. Using only audio was possible because the thesis author knew all the informants; this approach could have been challenging with total strangers.

The informants neither got a list of interview questions in advance nor were they provided with one at the beginning of the interviews. Instead, the thesis author had themes written on a sheet of paper to ensure that the relevant supply chain resilience topics were covered during interviews. Although some effort was made to have as natural discussions as possible, the interviews were closer to semi-structured than pure qualitative interviews. The themes were created based on the research questions and literature and included the following:

- Barriers
- Competencies
- Definitions
- Enablers
- Measurement
- Technology.

However, the themes were not strictly followed, and sometimes interviews took exciting paths. In addition to interviews, the thesis author had access to the company's internal presentation materials about supply chain resilience, such as all-hands-calls, related audio and video recordings, and supply chain resilience strategy materials providing some measure of data triangulation.

4.3 Coding process

Coding in qualitative research is about combining and categorizing data from, e.g., transcribed interviews based on some characteristics. The purpose of coding is to simplify rich qualitative raw data to become more manageable and to arrange data in ways that might develop into something new and surprising. (Juhila 2022.)

Microsoft Teams' live transcripts worked well, but there were also apparent mistakes requiring correction. The interviews were re-played, and revisions were made to the transcripts when needed. Without some automation, transcribing 10 hours of recorded audio resulting in more than 250 pages would have required much more time and effort.

The corrected transcripts were copied into Excel for the next steps of coding. Each interview had its own Excel sheet, and initial coding was done based on the interview themes. Text styles such as bold and underlined were used to highlight relevant areas. The codes were written in the adjacent columns. In the following rounds, new emerging codes were added. Next, selected coded sections were extracted from the text body and copied to sticky notes in the Miro online collaboration platform, adding a visual element to coding. This resulted in about 200

sticky notes. Existing codes were attached as tags to the notes, and new ones were added during subsequent reviews. The number of codes increased from less than ten initial themes to close to 30. During the coding in Miro, the sticky note clusters transformed from initial long vertical lists to distinctive groups. The newly clustered notes were migrated back to Excel because a detailed content analysis in Miro would have been challenging due to the limited amount of text fitting on a sticky note and the large number of coding tags per note.

4.4 Coding and analysis with the Gioia method

The final coding and analysis were conducted in Excel based on the Gioia method, i.e., establishing the 1st-order, 2nd-order, and 3rd-order codes. Informants' supply chain resilience definitions, which were typically discussed at the beginning of interviews as an orientation to the subject, were coded and analyzed separately in Table 5, and contributed mostly to the 1st research question, i.e., what does the concept of supply chain resilience mean for the case organization? Table 5 covers less than ten percent of the transcribed interview materials.

Discussions related to other listed themes and those that emerged naturally during the interviews were coded and analyzed in Appendix 2 and summarized in Figure 5 without a long list of 1st-order codes. These contributed to the 2nd and 3rd research questions, i.e., what factors influence supply chain resilience in the case organization and how can the case organization develop its supply chain resilience. Appendix 2 and its summary Figure 5 cover more than 90 percent of the transcribed interview materials. The relationships between research questions, related support materials (appendix, figure, and table), and the amount of transcribed interview materials are presented in Figure 4.

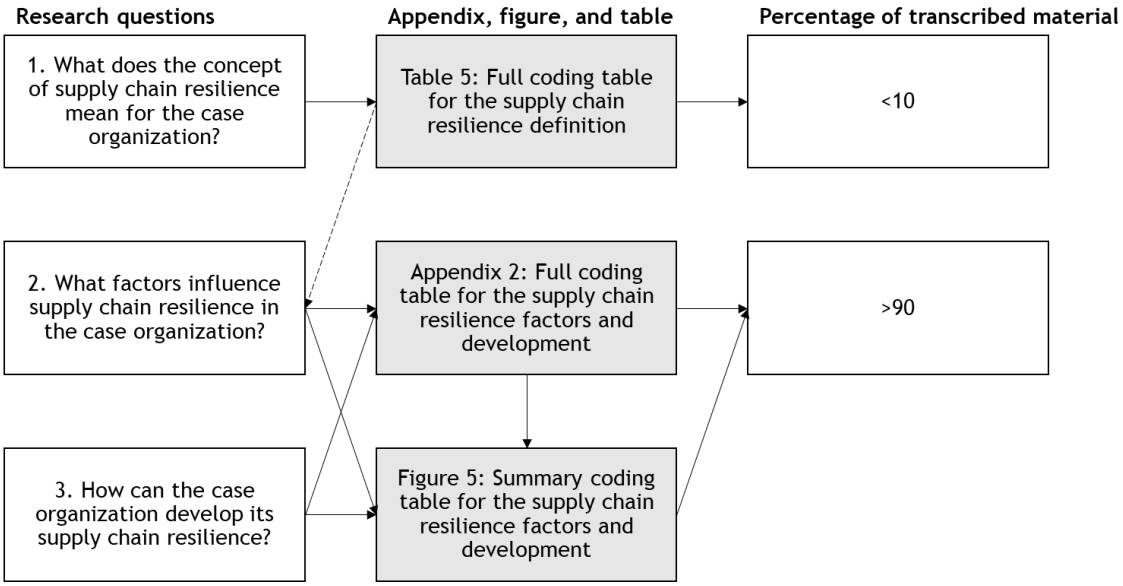

Figure 4: Relationships between research questions, related support materials, and the number of transcribed interview materials

Figure 4 helps the readers to navigate between the research questions, coding, analysis, and later, the results. Informants' 1st-order in vivo codes and the thesis author's 2nd-order thematic codes and 3rd-order conceptual codes in Appendix 2 and Table 5 provide the readers a window into informants' thinking and the thesis author's analysis and interpretation. Below Table 5 presents a full coding table for the supply chain resilience definition from which the new supply chain resilience definition for the case organization is created in chapter 5.1.

1st-order (in vivo)	**2nd-order (what)**	**2nd-order (how)**	**3rd-order coding**
1. Being able to manage problems. 2. Our ability to tolerate disturbances. 3. It is the ability to respond to all turbulences. 4. How can we absorb these disruptions in our supply chain without an impact? 5. Maintaining the ability to deliver even in difficult times, regardless of surprising events. 6. Supply chain resilience is the ability to navigate your supply chain through a crisis successfully. 7. How can the supply chain function and defend itself with internal changes against the pressure brought by external changes?	Capabilities; changes; crisis; decisions; different situations; disruptions; disturbances; problems; surprising events; turbulences	Adapt; absorb; defend; deliver; function; manage; navigate; recover; respond; tolerate	Ability

1st-order (in vivo)	2nd-order (what)	2nd-order (how)	3rd-order coding
8. Resilience is the ability to think further ahead in an anticipated way to be able to recover and adapt to changes and turbulences quickly.			
9. How flexible are we? 10. Having a plan A, B, and C. 11. It is a dynamic way of working. 12. Resilience is how we create diversification. 13. Resiliency means agility in decision-making. 14. We have an alternative from a capability standpoint. 15. You can allocate or reallocate material flows if something happens. 16. Responsiveness to changes and adaptability to longer-term changes. 17. Resilience is how agile you address those interruptions and turbulences. 18. To adapt the supply chain to the new landscape. 19. It is developing agility to switch, react, or proactively act to prevent disruptions even when the boundary conditions are changing.	Adaptability; agile / agility; alternative; changes; conditions; decision-making; disruptions; diversification; dynamic way of working; flexible; interruptions; material flows; plan (A/B/C); responsiveness	(Re)act; (re)allocate; respond; switch	Adaptability
20. We should have transparency about the Nokia delivery capability. 21. To be very transparent with customers and even internally with the supply chain. 22. Resiliency to me comes from real-time visibility. You need real-time visibility of information flow from upstream to downstream.	Customers; delivery capability; information flow; transparency / transparent; real-time visibility; supply chain; up / downstream	Be; have	Transparency
23. To have more systems of backup that allow us to continue to do business. 24. Develop a systematic approach to intercepting weak signals before events disrupt the supply chain.	Systematic approach; systems of backup	Develop	Systems thinking

1st-order (in vivo)	2nd-order (what)	2nd-order (how)	3rd-order coding
25. To think further ahead in an anticipated way. 26. How well are we prepared to absorb any disruptions? 27. To use weak signals to make proactive decisions. 28. We think long term and have many different scenarios in mind. 29. To intercept weak signals before events disrupt the supply chain. 30. To prevent disruptions even when the boundary conditions are changing.	Further ahead; long term; proactive decisions; different scenarios; weak signals	Decide; intercept; prepare; prevent; think	Future orientation
31. We must be more flexible in our distribution and source networks. 32. Like the Internet, if one node is not working, the Internet continues to work. 33. To create a network that provides the required mechanisms to back up each other. 34. Supply chain resilience would mean a workflow where I have nodes like planning, I have a node that says design, I have then supply, etc.	Distribution and source networks; Internet; network; node(s)	Backup	Network
35. What people focus means in resilience is that we take care of our people. 36. It is the ability of individuals and/or organizations to adapt to different situations positively.	Individuals; organizations; people focus	Care	People
37. How quickly can we recover? 38. How long can we continue to function? 39. We talk about being resilient in all senses, not just the speed of decision-making.	Long; quickly; the speed of decision-making	Continue; function	Time
40. Suppliers who can step in when we have a crisis. 41. How quickly can we move production to other sites? 42. How prepared are the other sites for testers, personnel, etc.?	Distribution and source networks; factories; material flows; testers; personnel;	Optimize; move; (re)allocate, step in	Supply chain orientation

1st-order (in vivo)	2nd-order (what)	2nd-order (how)	3rd-order coding
43. You can allocate or reallocate material flows if something happens. 44. The resilience of the supply chain comes from there as well; the better the product is optimized for the supply chain. 45. We must move products between factories flexibly and be more flexible in our distribution and source networks.	product(s); production; sites; suppliers		

Table 5: Full coding table for the supply chain resilience definition

Table 5 provides insights into how the 20 informants perceive the case organization's supply chain resilience and helps to answer mainly the 1st research question, i.e., what does the concept of supply chain resilience mean for the case organization? Table 5 contents are discussed in more detail in chapter 5.1.

Following Figure 5 presents the summary coding table for supply chain resilience factors and development. It is based on the full coding table for supply chain resilience factors and development in Appendix 2. Figure 5 excludes the long list of 1st-order codes for conciseness and helps to answer the 2nd and 3rd research questions, i.e., what factors influence supply chain resilience and how can the case organization develop its supply chain resilience. Readers wanting to read the 1st-order in vivo codes can visit Appendix 2.

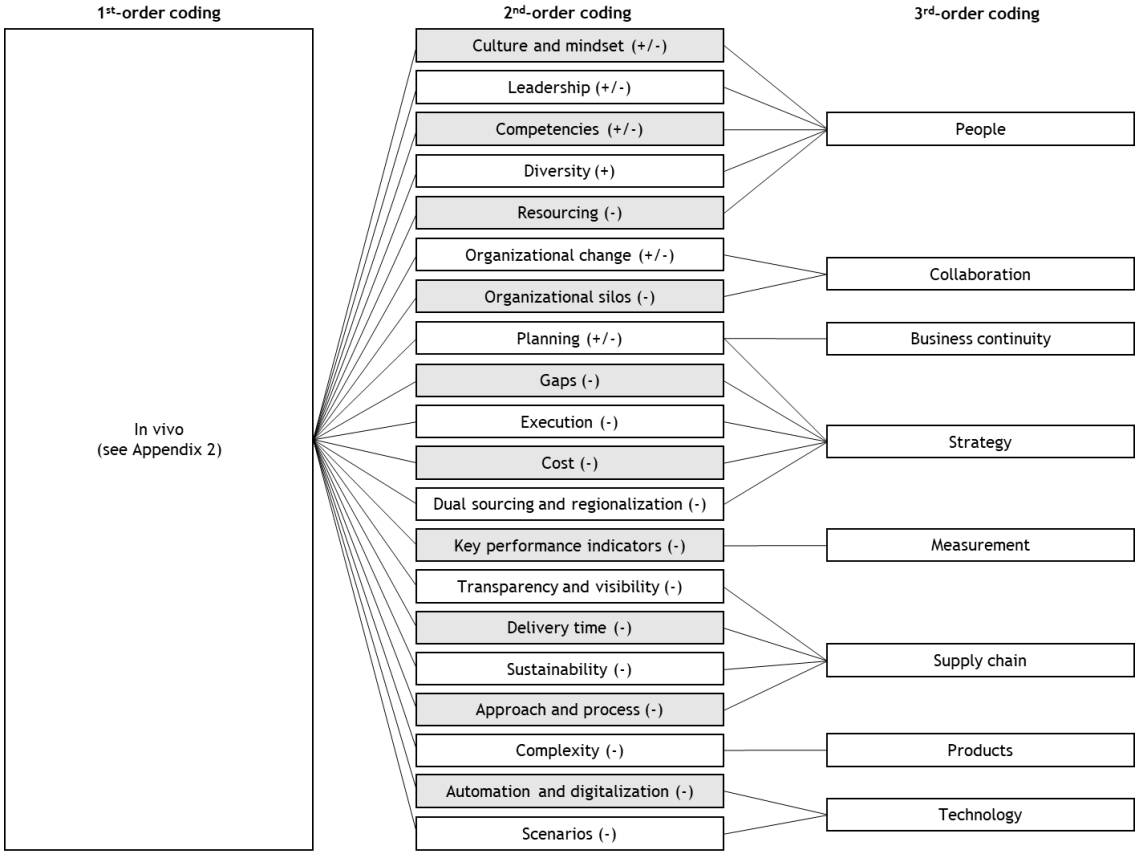

Figure 5: Summary coding table for the supply chain resilience factors and development

The light gray color in the 2nd-order coding section in the middle of Figure 5 is for visual aid only. The plus characters mean that the 1st-order in vivo codes, from which the 2nd-order thematic codes are derived, are associated with positive remarks suggesting potential supply chain resilience enablers. Similarly, the minus characters in the 2nd-order coding section mean that the 1st-order in vivo codes, which are visible in Appendix 2, are related to negative remarks suggesting potential supply chain resilience barriers. Some 2nd-order codes have both plus and minus characters associated with them. This means there are both underlying positive and negative 1st-order in vivo remarks in Appendix 2. Take the 1st item, i.e., culture and mindset (+/-), as an example. According to an informant: "*The company's mindset is no longer about cost efficiency. It is about resilience and efficiency, the change that needed to happen.*" This positive remark suggests a change in the case organization's culture and mindset, thus a potential supply chain resilience enabler. According to another informant, "*Always after crises, it has been recognized that we should review what has been learned, but somehow, we need to improve at the practical level in the implementation.*" This is a negative remark about the case

organization's culture and mindset, and thus a potential supply chain resilience barrier. Figure 5 contents are discussed in more detail in chapters 5.2 and 5.3.

4.5 Ethical considerations

Researchers must remember the classic do not harm principle when engaging and working with research participants and organizations to achieve their research objectives. In addition to moral obligations, there are legal codes researchers need to adhere to. (Saldana 2011, 24.) Regarding ethical considerations related to the thesis, most are related to collecting, managing, and presenting data collected through interviews. The thesis author ensured that data was handled appropriately and that informants felt safe. For example:

- Informants had the option to decline participation.
- At the beginning of the interviews, the purpose was revisited, and recording permission was obtained.
- The informants were told that the thesis author would ensure privacy and that others could not link individual comments back to informants.
- The file folder containing recordings and other identifiable data was stored in the thesis author's OneDrive and classified and protected using Azure information protection so that only the thesis author could access the files. The informants were referred to as numbers (1-20) in Excel and Miro, and there was a separate protected document linking the numbers to informants.
- The recordings and other identifiable data will be securely disposed of after the thesis project.

Another concern is the information classification of the selected few internal materials used for triangulation. According to Nokia's information classification and handling standard operating procedure (2021, 5), information classified as Nokia internal use can be freely shared within the extended enterprise, including employees and those with a non-disclosure agreement. Should small amounts of information under this classification be made public, this would not seriously impact the company. References to the materials classified as Nokia internal use were only done at a high level. Those references do not adversely affect the case organization but provide background and context for the internal supply chain resilience discussion. To be safe, the case organization's communications professional was consulted about using these materials.

The last ethical concern is how the presented findings are perceived by the informants, case organization, and its stakeholders and what impact those might have. Again, the thesis author's main guideline was not to do any harm, and he used his best judgment to balance between what is essential and valuable for the research and what might be considered harmful. Those items that were clearly leaning towards the latter were omitted. A PowerPoint summary of the main findings was sent to the informants, allowing them to comment.

5 Results

5.1 What does the concept of supply chain resilience mean for the case organization?

This is the 1st research question. Although literary supply chain resilience definitions share common characteristics, such as emphasis on readiness, response, recovery, and growth, there is no universally accepted definition (Hohenstein et al. 2015, 107-108). Therefore, organizations need to study existing definitions, or develop their own, to increase supply chain resilience awareness and facilitate related discussions with their stakeholders.

The full coding table for the supply chain resilience definition in Table 5 provides a comprehensive overview of how the case organization's informants view supply chain resilience. The 1st-order in vivo codes are selected excerpts from the interviews in which the informants discuss their supply chain resilience definitions. The 2nd-order thematic codes based on the thesis author's analysis break down the excerpts into **what** and **how** components. The 1st consists mainly of substantives explaining against what the case organization should be resilient (changes, crises, different situations, etc.), although there are adjectives and adverbs, such as long and quickly, as well. The 2nd consists of verbs explaining the way the case organization should act when facing supply chain disturbances or disruptions (adapt, absorb, defend, etc.).

There are nine 3rd-order conceptual categories of supply chain resilience: **ability**, **adaptability**, **future orientation**, **network**, **people**, **supply chain orientation**, **systems thinking**, **time**, and **transparency**. When supply chain disturbances or disruptions occur:

- Being **able** to act can separate organizations that survive from those that perish.

- **Adaptability** can help organizations to create diversified and flexible contingency plans and alternate paths through crises.
- **Future orientation** can manifest as anticipation and preparation for known and unknown future challenges.
- **Network** and **systems thinking** can help organizations recognize and appreciate the interdependencies of the different parts of the supply chain and provide redundancies.
- **People** and their abilities can help organizations to make a difference between success and failure; the same applies to **time**.
- **Supply chain orientation** can help organizations to focus on those system or network elements that are the most crucial for maintaining the capability to deliver products and services.
- **Transparency** can increase organizations' decision-making speed and quality.

It is worthwhile noticing, that while the above 3rd-order conceptual codes provide input mainly to the case organization's supply chain resilience definition, those provide also hints about what factors might influence supply chain resilience in the case organization, hence the dotted line in Figure 4. Common 3rd-level coding elements between Table 5 and Figure 5 include **people** and the **supply chain** (orientation). Also, the 3rd-level code **transparency** in Table 5 corresponds to the 2nd-level code **transparency and visibility** in Figure 5. By combining the thematic 2nd-order and conceptual 3rd-order codes from Table 5, it is possible to construct a comprehensive supply chain resilience definition for the case organization:

Supply chain resilience is the case organization's ability to defend against disturbances, absorb and tolerate impact, respond to disruptions, navigate crises, and recover while maintaining function to deliver. It is a dynamic way of adapting to changes by diversification, switching between plans, reacting in agile and flexible ways, and reallocating material flows. It builds on real-time transparency to customers, information flows, and delivery capability. It requires systems thinking and a network of backups. It has a future orientation and focuses on weak signals and scenarios to prepare for what is ahead. It is also about people and caring for individuals. Supply chain resilience is about time and speed of decision-making. Finally, it is about supply chain orientation to optimize networks and production, reallocate material flows, equipment, and personnel, move products between factories and sites, and have suppliers who can step in.

This supply chain resilience definition emerging from interviews, coding, and analysis is more detailed than the literature definitions in Table 3 and the thesis

author's definition in chapter 3.1.3. However, what is still missing are explicit references to the relevant processes, growth, and learning. In contrast, a reference to people is missing from the earlier definitions. The first sentence, i.e., "*supply chain resilience is an organization's ability to defend against disturbances, absorb and tolerate impact, respond to disruptions, navigate through crises, and recover while maintaining function to deliver*," is similar to the literature definitions and can be used as a shortened version of supply chain resilience definition for the case organization. While the short version might serve some stakeholders better, the thesis author believes that the whole definition offers more opportunities for meaningful supply chain resilience discussions simply because it has more details and mental hooks.

5.2 What factors influence supply chain resilience in the case organization?

5.2.1 General findings

This is the 2nd research question. According to Hohenstein et al. (2015, 105), supply chain resilience factors include agility, collaboration, flexibility, human resource management, inventory management, predefined decision plans, redundancy, and visibility. Spieske & Birkel (2021, 8) find that collaboration, sourcing, supply chain design, supply chain understanding, supply chain risk management culture, velocity, and visibility are essential to supply chain resilience. Agarwal et al. (2022, 749-750) present a comprehensive list of supply chain resilience factors, i.e., business intelligence mechanisms, collaborative decision-making, collaborative forecasting, collaborative operations, contract flexibility, distribution and logistics flexibility, local backup suppliers, information tracking mechanisms, information sharing mechanisms, multi-skilled workforce, real-time information, proactive identification, production flexibility, quick action, reserve capacity, and sourcing flexibility. Are these and other factors discussed in the theoretical background visible in the case of organization-related supply chain resilience findings?

Figure 5 presents 20 thematic 2nd-order codes and eight conceptual 3rd-order codes. These codes provide insights into the case organization's supply chain resilience factors and development. While the conceptual 3rd-order codes provide an abstract summary or convenient placeholders for the thematic 2nd-order items, an interesting finding is that the 2nd-order codes are much more actionable, and therefore, the focus is mostly on those. Figure 5 is based on Appendix 2, where three 1st-order in vivo excerpts were chosen to represent each 2nd-order thematic code, except in the cases of **diversity** and **sustainability**, for which there is only one representative excerpt.

Comparing researchers' lists to the codes in Figure 5, it is easy to find similarities and differences. What is common is references to visibility and a high degree of the human element, e.g., collaboration, human resource management, and supply chain risk management culture in the literature, and **competencies**, **culture and mindset**, **leadership**, etc., in the 2nd-order coding section in Figure 5. Although the role of **automation and digitalization** is on the rise, supply chain resilience is still very much about people and how they interact. This aligns with the view that soft skills are essential in building and maintaining business continuity. (Continuity and Resilience Report 2022, 35-36). However, because of the case organization's growing dependence on digital tools, one would expect a particular focus on cyber security, but this topic did not surface spontaneously in the interviews. Interestingly, the role of **organizational change** and **silos** in supply chain resilience development is not explicitly visible in the literature, although these are related to collaboration.

5.2.2 Overview of the supply chain resilience factors

The overview is arranged alphabetically with a few exceptions. Starting from the **approaches and processes** listed in the 2nd-order coding section in Figure 5 (and Appendix 2 for readers preferring to review the related 1st-order codes at the same time) some appear outdated and ineffective, which can hurt supply chain resilience. For example, the recent crises have forced the case organization to work in an exception management mode for extended periods, increasing the amount of manual work and burden for the employees. Furthermore, there seem to be challenges in turning intelligence into actionable insights.

Due to insufficient **automation and digitalization**, managing the complex environment effectively and efficiently is challenging. There seem to be issues with data quality and investment in automation and digitalization capabilities, which are also needed for demand and supply forecasts, portfolio analysis, risk management, and **scenarios**.

Competencies seem to be both supply chain resilience enablers and barriers. Generally, the organization's members seem to have good skills and experience, enabling them to confront challenging situations at work. However, there seem to be competence gaps in data analysis, tool development and use, out-of-the-box thinking, soft skills, and project and resource management.

Complexity may be an inherent quality of the case organization's operating environment, and it is visible especially in the product portfolio. There are more products in general, and customer-dominant products have increased. Furthermore,

5G has significantly increased the number of product variants. Many individual components must be purchased at the right time in the right amount from numerous suppliers.

The **cost** of supply chain resilience is seen as a significant obstacle in the case organization. The resources are scarce, and there are always competing investment and project proposals, so it is all about prioritization. For example, limited resources have been available for supply chain resilience development because of the roadmap prioritization needed to catch up with the competition in the past.

It seems that **culture and mindset** are supply chain resilience enablers and barriers for the case organization. For example, the positive can-do attitude encourages employees and leaders to put in extra effort when required, which is a strength. However, a reactive approach to crisis management combined with the case organization's strong track record in overcoming supply chain disturbances and disruptions may result in a false sense of security. All these, combined with missed lessons learned opportunities, can strengthen the bias towards a reactive crisis management approach when a more forward-looking approach would be more appropriate. An informant put it briefly: "*When the situation calms down, it is like a back pain: when it hurts, you do some exercise and get it back in shape, but when the pain disappears, the urge to exercise also decreases*."

Delivery time, which is also an important key performance indicator, was referred to by some informants as a challenge for the case organization. For example, finding the right contacts or escalation points to speed up the process can be challenging, leading to missing customer commitments. Also, some competitors appear faster in their customer deliveries.

Dual sourcing and regionalization gaps became visible during the triple fault **scenario**, i.e., the pandemic, semiconductor shortage, and war in Ukraine. In addition, inventory management under the current dual sourcing and regionalization approach may be challenging, and the case organization must ensure that inventories are built in the right places.

Execution of the strategy and related plans is crucial for the case organization to reach organizational goals. The challenge is that even though good actions are ongoing in the supply chain resilience area, implementing supply chain resilience-related projects can take more than one year. Only after the projects are completed do the results become visible.

Gaps can be found in strategies, plans, and execution; the case organization is no exception. For example, according to the informants, more effort could be put into promoting innovativeness and openness, addressing different customers and markets, and ensuring the overall execution of the strategy.

Regarding **key performance indicators**, it appears that much effort is put into thinking about and measuring activities and performance, but the indicators are primarily reactive. Furthermore, there might be conflicting goals between the product programs and the supply chain, which might harm execution. In addition, there are good key performance indicators, e.g., in the manufacturing, transportation, and warehousing areas, but the holistic end-to-end view seems to be missing.

Leadership seems to be both a supply chain resilience enabler and a barrier for the case organization. For example, top leaders have demonstrated exemplary commitment, engagement, and support, which is crucial, especially in supply chain disturbance and disruption situations. At the same time, the higher you go in the organization, the less understanding there can be about practical matters, and things can appear black or white. Furthermore, despite a heavy emphasis in the case organization on psychological safety to unlock human potential and innovation, there can still be cases where Nokia's principles are not lived wholly.

Over two years ago, Nokia underwent an **organizational change** resulting in a business group-driven model. According to the findings, the new organizational structure, where the supply chain is within the MN instead of a centralized and separate function, positively influenced the case organization's capability to overcome the triple fault scenario. An informant suspected that should the case organization has faced the pandemic, semiconductor shortage, and war in Ukraine in the old organizational set-up, it would not have been possible to manage the supply chain disturbances and disruptions as effectively and efficiently. The organizational change appears to be both a supply chain resilience enabler and a barrier. There seems to be a common interest, cooperation, and trust. In addition, R&D and the supply chain are now closer. At the same time, however, the results suggest a lack of willingness to work across organizational boundaries, the mode of operation being silo-driven, and the supply chain being too heavily compartmentalized, leading to a loss of synergies.

Organizational silos can feel safe; many people may be accustomed to working in a compartmentalized structure. Therefore, during supply chain disturbances and disruptions, they might easily slip back to the old and siloed ways of working,

although overcoming challenges would require the exact opposite. Nokia has had its share of challenges related to strong organizational cultures. It has gone through a series of significant mergers, acquisitions, and partnerships with, e.g., Siemens (2007), Microsoft and Motorola (2011), and Alcatel-Lucent (2016) (Nokia 2021a, 22-23). All these companies had distinctive organizational cultures and establishing common frameworks and structures has not always been easy.

Planning, too, seems to be both a supply chain enabler and a barrier. Informants seem to have a favorable view of the case organization's business continuity planning in general. Furthermore, almost all informants believe that the current supply chain strategy is good, and most of the barriers to resilience are addressed in the latest version of the strategy. However, although the plans are comprehensive, there are some gaps, as mentioned earlier. In addition, the case organization's past challenges related to minimal stocks and prioritizing technology development over resilience to ensure successful transformation still seem to influence the case organization negatively.

Resourcing is crucial because many parallel initiatives, projects, and programs depend on the same resources. This can hurt project execution and influence key resources' well-being negatively. As mentioned earlier, there appear to be some competence gaps in the project and resource management area. However, the case organization's multinational set-up and **diversity** are strengths that can help overcome resourcing and skill-related challenges.

Sustainability goals may sometimes seem to conflict with resilience goals. Conflicting goals may force organizations to make trade-offs, such as choosing between waste reduction, a sustainability goal, and inventory flexibility, a resilience goal (Rajesh 2021, chap. 2.1. Focus on efficiency/focus on flexibility). However, resilience and sustainability goals can also be aligned and support each other. For example, increasing regionalization, a resilience goal, can reduce logistics' greenhouse gas emissions, a sustainability goal.

Regarding **transparency and visibility**, the case organization should go much deeper into their suppliers' supply chains and have better visibility into sub-tier suppliers. Furthermore, it appears that the different parts of the supply chain have different levels of transparency and visibility, which is not optimal and can lead to misalignment. In addition, transparency and visibility should be supported by processes and technology linking this topic to digitalization and processes discussed earlier in this chapter.

5.3 How can the case organization develop its supply chain resilience?

This is the 3rd and last research question of the thesis. Based on previous chapters, let us investigate what the case organization could do to improve its supply chain resilience. An easy answer would be to leverage the case organization's strengths and eliminate its weaknesses. The case organization clearly understands the need for increased supply chain resilience and has a working strategy backed up by the management. This is a good start.

Working on the **approaches and processes** could improve the effectiveness and efficiency of many activities in general and help the case organization fight against future supply chain disturbances and disruptions. In addition, process improvements could positively influence challenges such as those related to automation and digitalization, complexity, delivery time, execution, key performance indicators, organizational silos, resourcing, and transparency and visibility.

Regarding **automation and digitalization**, there are already ongoing projects, e.g., digital twin (Celebrating one year of our #MNSCstrategy 2022). According to Ivanov & Dolgui (2021, 783), digital twins can help organizations increase supply chain resilience through fast and reliable issue recognition that enables organizations to navigate crises and avoid or minimize the negative impact on supply chains. The digital twin framework for supply chain disruption management described in Figure 2 can be used to improve supply chain resilience in the case organization. Furthermore, digital technologies, such as advanced manufacturing, artificial intelligence, big data analytics, the internet of things, and machine learning, can have a positive impact on supply chain resilience if the organization has high enough digital maturity and tool adoption levels (Zouari, Ruel & Viale 2021, 149). Digital maturity and tool adoption should pose no significant challenges for the case organization despite the competence gaps and the diverse data, technology, and tool ecosystems resulting from Nokia's long history of acquisitions, mergers, and partnerships. For example, Nokia's 5G factory in Oulu, Finland, was selected in 2019 as an advanced 4th industrial revolution lighthouse, a testament to implementing Industry 4.0 technologies at scale with proven success (Nokia 2019). In addition, Nokia is building a new functional, scalable, and sustainable Oulu campus that enables the best workplace experience that meets collaboration, flexibility, innovation, and productivity requirements (Nokia 2021b). This greenfield approach allows the case organization to implement all the latest digital technologies and tools to increase supply chain resilience and efficiency.

In addition, improving **competencies** related to data analysis, tool development and use, out-of-the-box thinking, soft skills, and project and resource management can positively impact, e.g., automation and digitalization, scenarios, leadership, and execution. Investing in people is a common approach to addressing current and future business challenges. The case organization has four basic options: 1) improving employees' competencies by education, training, and learning on the job, 2) recruiting new employees with the needed competencies, 3) using 3rd parties such as consultants and professional project managers, 4) partnering up with schools and universities. Many organizations use all options, each having advantages and disadvantages. For example, improving employees' competencies can take time, but they are already familiar with the organization. Recruiting new employees having the needed competencies is faster, but they need a proper induction. New employees can also challenge the existing culture, approaches, processes, and working methods and bring new and innovative ideas. Using 3rd parties can also be faster than improving employees' competencies, but they also need to learn about the organization. Furthermore, this option can be costly, and the organization needs to ensure that a knowledge transfer benefits it in the long term. In addition, using external consultants and project managers can be frowned upon by the employees. The last option, i.e., working with schools and universities, requires onboarding on both sides. However, if the collaboration succeeds, the organization can access a fresh talent pool.

Reducing the number of individual components, suppliers, and product variants can help to reduce product portfolio-related **complexity**. Furthermore, automation and digitalization can support handling vast amounts of component, supplier, and product-related data effectively and efficiently. Regarding the current initiatives, design for supply chain can help the case organization to address product and portfolio-related complexities by, e.g., optimization and reuse (MN Supply Chain Strategy 2022).

The **cost** of supply chain resilience is influenced, e.g., by past and current decisions and their consequences. Lack of sufficient resources to build, maintain and strengthen supply chain resilience capabilities can harm the case organization long term if not appropriately addressed. The case organization needs to continue its chosen technology leadership path to ensure future competitiveness. This is likely to influence sales and revenue positively. Increased revenue can then be invested in new supply chain resilience projects. Furthermore, the case organization should aim for the balanced resilience approach where no excessive resilience capabilities lead to increased costs and no extreme vulnerabilities lead to increased risks (Pettit et al. 2010, 7).

Culture and mindset are supply chain resilience fundamentals. The case organization can continue leveraging the positive aspects, including the can-do attitude that has helped it through many challenging situations, while finding ways to move from reactive toward more proactive ways of working, including conducting lessons-learned exercises systematically. As mentioned in the previous chapter, the firefighting approach, which has been quite successful in the past, can create a false sense of security in the ability of the case organization to overcome any supply chain disturbance or disruption. Should the leaders and employees perceive no need for a change and continue working the same way, the case organization needs to overcome this change resistance. Alternatively, it may face an insurmountable future crisis forcing it to adopt a more forward-looking approach.

Delivery time is a result of many separate but interconnected processes. While the case organization can control most processes, external factors can still negatively influence delivery time. There are already ongoing activities in the areas of, e.g., digitalization, planning, standardization, supply chain network agility, flexibility, and transparency, impacting the delivery time positively (MN Supply Chain Strategy 2022).

Dual sourcing and regionalization are important aspects of supply chain resilience for the case organization. There are ongoing actions to defend the case organization from, e.g., geopolitical, market, and material availability-related challenges (MN Supply Chain Strategy 2022). Dual sourcing and regionalization can also impact delivery time positively and reduce logistics' greenhouse gas emissions, helping the case organization to reach its **sustainability** targets.

Flawless **execution** of the strategy and plans is crucial for the case organization to meet its objectives. Therefore, it needs to address current challenges, e.g., project and resource management, competence gaps, and organizational barriers to collaboration, including silos. In addition to the execution **gap,** the case organization needs to focus on customers and markets because customers can have different expectations, and market dynamics can also be very different. Furthermore, the case organization needs to be vigilant and observe the weak signals that might predict customer and market changes.

Regarding **key performance indicators**, measuring supply chain resilience effectively and efficiently requires effort. According to an informant, "*A massive end-to-end KPI does not say anything about this matter*," aligning with Bret, Dussud, Metral, Ladier & Trilling (2021, 17) saying that measuring supply chain resilience with only one reliable indicator is difficult. Much effort is already put into

the key performance indicators, but they do not seem to measure supply chain resilience effectively. Current challenges include, e.g., the amount of manual work, conflicting goals, history focus, and the lack of end-to-end visibility. Four informants emphasized customer feedback in supply chain resilience measurement. One can reasonably argue that customers' perception of the case organization's delivery performance is the ultimate although reactive way to measure supply chain resilience. Other informants' thoughts about supply chain resilience measurement include, e.g., actual execution versus plans, inventory health, and value at risk. According to an informant, the case organization should change the key performance indicator if it is the wrong measurement in the current situation instead of stubbornly following it.

Leadership is essential in the case organization's supply chain resilience development. Leaders need to continue to offer their commitment, engagement, and support in the future. Furthermore, leaders can try to understand both the practical and high-level supply chain resilience topics better and appreciate all shades of gray instead of categorizing things as black or white. In addition, leaders can leverage the increased trust and closer collaboration between R&D and the supply chain. Moreover, they can engage in organizational development, break down the **organizational silos**, and ensure that Nokia's essential principles are followed to create a thriving and safe working environment.

Regarding **planning**, many topics related to strategy and execution have already been discussed in this chapter, so the focus is on the case organization's business continuity planning in this context. Although informants seem to have a favorable view of business continuity plans, the case organization needs to continue following the update and testing cycles to ensure that the plans can be used effectively and efficiently in future supply chain disturbance and disruption situations.

Resourcing projects and programs appropriately and ensuring project managers have the needed competencies are essential to ensure that the projects meet the required cost, scope, time, and quality targets. Although projects can take over a year to complete, the case organization's supply chain resilience will continue to improve gradually.

Creating **scenarios** seems to consume lots of time and resources in the case organization. Advances in automation and digitalization will provide case organization's supply chain professionals with more tools to simulate different demand and supply situations, understand the impact of supply chain disturbances and disruptions, and model practical mitigation actions. However, what the case

organization can do already now is to engage in what–if thinking on a larger scale. While this low-to-no tech option does not necessarily provide an immediate operational or tactical advantage, it can help the case organization think about possible futures in the long term and how to act in new circumstances ahead of the competition.

Transparency and visibility are influenced by many other topics already discussed in this chapter. To better understand the sub-tier suppliers, the case organization can partner with its 1st tier suppliers, conduct surveys, and use automation and digitalization to map supply chain tiers to the desired levels. Automation and digitalization combined with an end-to-end process view and relevant key performance indicators can also help improve transparency and visibility across organizational boundaries. This can increase, e.g., the speed and quality of decision-making. Furthermore, the case organization can adopt the ABCDE supply chain visibility framework described in Figure 3 to improve in this area.

Lastly, when informants discussed what would they change if they had the power to do anything, this is what they proposed:

- "*First of all, be closer to our customers.*"
- "*I would start connecting the dots from the sell process.*"
- "*The key component is suppliers' geographical positioning.*"
- "*It would be the quality of the decision-making and then the speed.*"
- "*Full end-to-end digitalization with high data quality would help greatly.*"
- "*I think that if we had a more streamlined portfolio, this would make our life much easier.*"
- "*We need to speed up our integrated system and have more flexibility in our demand plan.*"
- "*If you had this true Lego principle, whatever you want – a castle, ship, or motorbike – you can just build it.*"
- "*I think the most relevant part is the manufacturing footprint.*"
- "*I would take special urgency to make sure we did not get caught on any of those what I call a kind of disaster sole source.*"

These views represent the findings in general; no breakthrough ideas emerge from this discussion. For example, references to a streamlined portfolio and the Lego principle relate to informants' views about product variants and complexity. Because supply chain resilience constantly evolves, the case organization should adopt a maturity model for supply chain resilience baselining and development. This is the topic of the next chapter.

5.4 Weak market test for the supply chain resilience maturity model proposal

As mentioned in chapter 3.2.3, there seems to be little research on using supply chain resilience maturity models for supply chain resilience measurement and development. Ali et al. (2017, 16) provide the most comprehensive conceptual supply chain resilience framework identified during the thesis study. It covers over 100 peer-reviewed journal articles written over six years and lists five supply chain resilience capabilities, over ten essential elements, and more than 80 managerial practices that are relevant to supply chain resilience. The supply chain resilience conceptual framework is presented in Appendix 1. The thesis author proposes that the case organization uses this framework as a basis for its supply chain resilience maturity model that can be used to develop supply chain resilience systematically in the long term.

To make a case for the proposal, the thesis author presented it in an MN COO SC Operations & Transformation biweekly team meeting on the 13th of December, 2022. The team's mission is to drive supply chain transformation by challenging the status quo and creating and executing strategy in collaboration with key stakeholders to enable MN's business success. The team concluded that developing and piloting the supply chain resilience maturity model based on the framework makes sense, thus supporting the weak market test. In addition, the thesis author presented the team with preliminary interview coding results, which the team members found interesting and relevant. Many colleagues agreed with the informants' views; some even had personal experiences about the presented findings. This provided additional support regarding the overall credibility of the results.

6 Conclusions

6.1 Value of study

The main aims of this thesis are to understand and develop the case organization's supply chain resilience. The interviews, coding, and analysis reveal what the case organization's leaders think about supply chain resilience and answer the 1st research question, i.e., what does the concept of supply chain resilience mean for the case organization? The nine 3rd-order conceptual categories of supply chain resilience, i.e., **ability**, **adaptability**, **transparency**, **systems thinking**, **future orientation**, **network**, **people**, **time**, and **supply chain orientation,** combined with the 2nd-order thematic codes about **what** and **how** produce an emerging definition for the case organization's supply chain resilience. Here is the short version:

Supply chain resilience is the case organization's ability to defend against disturbances, absorb and tolerate impact, respond to disruptions, navigate through crises, and recover while maintaining function to deliver.

The short definition aligns with the literary definitions presented in chapter 3.1.3. It can be used in supply chain resilience-related communication, development, and education, although the extended definition provides more substance and support for these activities.

Regarding factors influencing supply chain resilience in the case organization, the topic of the 2nd research question, the research identifies 20 thematic 2nd-order codes, i.e., **approach and processes**, **automation and digitalization**, **competencies**, **complexity**, **cost**, **culture and mindset**, **delivery time**, **diversity**, **dual sourcing and regionalization**, **execution**, **gaps**, **key performance indicators**, **leadership**, **organizational change**, **organizational silos**, **planning**, **resourcing**, **scenarios**, **sustainability**, and **transparency and visibility**. These are clustered under eight aggregate 3rd-order conceptual codes, i.e., **business continuity**, **collaboration**, **measurement**, **people**, **products**, **supply chain**, **strategy**, and **technology**.

Focusing on the above 2nd-order thematic codes, which are more actionable compared to the 3rd-order conceptual codes, the thesis author proposes **actions** on how the case organization can systematically develop its supply chain resilience, thus answering the 3rd and final research question. Those actions are described in chapter 5.3. In addition, based on the literature study, the thesis author proposes that the case organization builds and adopts a **supply chain resilience maturity model** based on the supply chain resilience framework described in Appendix 1. This supports the case organization in its long term systematic supply chain resilience development.

In summary, the main value of the thesis to the case organization is that by understanding the supply chain resilience concept, influencing factors, and actions with which it can develop supply chain resilience, the case organization is better prepared to confront future supply chain disturbances and disruptions. This can have a positive impact on the case organization's financial performance, too.

6.2 Transferability of research

Because the thesis focuses on understanding and developing supply chain resilience in the Nokia Mobile Networks business group, the findings primarily apply in that context. However, results are relevant to other Nokia business groups as well

because supply chains share, e.g., some of the same processes, suppliers, systems, and tools. Also, there is a collaboration between the business groups on many supply chain-related topics.

Furthermore, findings may benefit other organizations in the telecommunications sector. However, all results are not industry-specific, so certain themes and concepts probably resonate with other private, public, or non-profit organizations operating supply chains regardless of industry. For example, **people**-related **culture and mindset**, **leadership**, **diversity**, and **resourcing** are common supply chain resilience themes for many organizations, although related enablers and barriers may differ. Therefore, all actions and proposals may not suit their unique circumstances as such but require further investigation and adaptation. Although most informants are from Europe, some effort was made to incorporate views from other regions. Therefore, the results are not region specific either, although implementing actions and proposals may require local adjustment.

6.3 Opportunities for further research

It is good to remember that the thesis results are not absolute truths but rather snapshots of the current situation perceived by the informants and interpreted by the thesis author. This means the case organization's supply chain resilience level today will not be the same in the coming months and years. The on-time delivery requested measurement (OTDr) is a case in point. Informants have some concerns about the case organization's delivery time. Based on the latest OTDr results, the situation has improved significantly compared to when the interviews started in June 2022. It would be great to conclude that the supply chain strategy and all related actions are behind this positive change, but that would require further research to confirm this.

There are three main opportunities for further research and three other options. The 1st main opportunity for further research is related to the case organization's emerging supply chain definition, which is not yet shared by all relevant stakeholders. What would it require from the case organization to ensure that employees and other stakeholders understand what supply chain resilience means for them in practice? The case organization can engage in various change management activities, e.g., communication and training that need to be tailored based on stakeholders' needs and requirements. Furthermore, combining theoretical supply chain resilience definition with practical supply chain resilience actions can help bridge the possible gaps in stakeholders' understanding. The proposed supply

chain resilience maturity model discussed next can also be used as a concrete vehicle for learning and understanding.

The 2nd main opportunity for future research is related to the proposed supply chain resilience maturity model based on the supply chain resilience framework presented in Appendix 1. What would it require from the case organization to build such an effective model? How should the case organization deploy it effectively? The case organization can, for example, review all managerial practices, select and describe the most relevant ones and establish a scoring system. The scoring can be done based on a simple binary yes or no approach, i.e., either the managerial practice is in place, or it is not. However, a more actionable approach is to use a predetermined scale, e.g., from 1 (low) to 5 (high). These values represent different supply chain maturity levels which need to be described in detail to have practical value. Once all practices have been evaluated and scored, the case organization can calculate scores for all elements and capabilities, identify potential strengths and weaknesses, and calculate the total supply chain resilience score for the case organization. This exercise can be repeated, e.g., at the beginning of each strategy and annual planning cycle to ensure systematic supply chain resilience development.

The framework can also be used as a diagnostic tool requiring less time and effort. The case organization's current and planned supply chain resilience activities can be plotted onto the framework to ensure relevant supply chain resilience capabilities, elements, and managerial practices are covered. Should the case organization learn that there are concentrations in one or several areas, this can mean one of two things: either the case organization identified gaps and decided to focus on those, or the case organization failed to adopt a systems approach and neglected essential areas of supply chain resilience. Regardless of whether the case organization uses the framework as a maturity model or diagnostic tool, collaboration across organizational boundaries is required, because of the needed experience, knowledge, and skills.

The 3rd main opportunity for further research is related to cyber security. As mentioned in chapter 5.2.1, this topic did not surface spontaneously during interviews. This does not mean, however, that there are necessarily gaps in this area, but it would be interesting to study what is the current level of supply chain cyber security in the case organization and how it plans to increase its capabilities in this area while pursuing further **automation and digitalization**. This is a good candidate for an internal study because the results cannot probably be shared publicly.

The 4th opportunity for further research is to dive deeper into the **culture and mindset**, **leadership**, and **organizational change** all of which are identified as being both supply chain resilience enablers and barriers. It would be interesting to study whether different generations have different views about these. Following the massive employee churn after the pandemic, it is critical to understand what engages and motivates generations Y (1980-1996) and Z (1997-the early 2010s) in the workplace (Kuzior, Kettler & Rąb 2022, 3). This is relevant because of the aging workforce in many countries and the global shortage of talent in general.

The 5th opportunity for further research is to study how activities performed mainly outside the supply chain affect the case organization's supply chain resilience. Examples of such activities include customer communication, contracting, financing, and pricing. This is relevant because some decisions made outside the supply chain can significantly influence supply chain performance and resilience.

The 6th and final opportunity for further research is studying the case organization's supply chain resilience from different perspectives, e.g., viewing it through the six areas of resilient growth (Görner et al. 2022) or nine resilience concept and application areas (Shishodia et al. 2021, chap. 2 Literature review). It would be interesting to study, how would a change in supply chain resilience perspective influence the case organization's supply resilience actions and proposals.

6.4 Reflections

In hindsight, the thesis author could have focused on a selected supply chain resilience topic, such as a particular supply chain disturbance or disruption phase (before, during, or after), strategy (proactive, concurrent, or reactive), capability (ability to anticipate, adapt, respond, recover, or learn), element (situational awareness, robustness, knowledge management, security, visibility, flexibility, redundancy, collaboration, ability, contingency planning, market position, or social capital), or one of the many managerial practices listed in Appendix 1. This could have resulted in a more focused study and results. However, the thesis author wanted to acquire as comprehensive a picture of the supply chain resilience phenomenon as possible to increase his understanding and support the case organization in its supply chain resilience development journey.

In closing, considering Nokia's close to 160-year history, the company started as a single paper mill operation, transformed into a conglomerate, and emerged as a leading technology company that has survived many internal and external challenges (Nokia 2021a, 22-23). Therefore, one can argue that resilience is part of the company's DNA. Despite this heritage, one should also keep in mind that decisions

impacting the case organization's supply chain resilience are done daily. Supply chain disturbances and disruptions are not necessarily harmful, and related challenges can be viewed as opportunities for growth. As an informant put it: "*I think that we might not have been as resilient as we are now if it had not been for all these things that happened. If things are going well and there are no problems, there is no reason to change*."

References

Electronic

Agrawal, N. & Jain, R.K. 2021. Insights from systematic literature review of supply chain resilience and disruption. Benchmarking: An International Journal, 29 (8), 2495-2526. https://doi-org.nelli.laurea.fi/10.1108/BIJ-02-2021-0084

Agarwal, N., Seth, N. & Agarwal, A. 2020. Modeling supply chain enablers for effective resilience. Continuity & Resilience Review, 2 (2), 97-110. https://doi-org.nelli.laurea.fi/10.1108/CRR-05-2020-0017

Agarwal, N., Seth, N. & Agarwal, A. 2022. Evaluation of supply chain resilience index: a graph theory based approach. Benchmarking: An International Journal, 29 (3), 735-766. https://doi-org.nelli.laurea.fi/10.1108/BIJ-09-2020-0507

Aggarwal, S. & Srivastava, M.K. 2019. A grey-based DEMATEL model for building collaborative resilience in the supply chain. International Journal of Quality & Reliability Management, 36 (8), 1409-1437. https://doi-org.nelli.laurea.fi/10.1108/IJQRM-03-2018-0059

Ali, A., Mahfouz, A. & Arisha, A. 2017. Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. Supply Chain Management, 22 (1), 16-39. https://doi-org.nelli.laurea.fi/10.1108/SCM-06-2016-0197

ASCM 2023. Introduction to processes. Accessed 9 January 2023. https://scor.ascm.org/processes/introduction

Behzadi, G., O'Sullivan, M.J. & Lennon Olsen, T.L. 2020. On metrics for supply chain resilience, European Journal of Operational Research, 287 (1), 145-158. https://doi.org/10.1016/j.ejor.2020.04.040

Blanchard, D. 2010. Supply Chain Management Best Practices. Hoboken: John Wiley & Sons. Accessed 20 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=514332

Brende, B. & Sternfels, B. 2022. Resilience for sustainable, inclusive growth. McKinsey & Company. Accessed 11 August 2022. https://www.mckinsey.com/business-functions/risk-and-resilience/our-insights/resilience-for-sustainable-inclusive-growth

Bret, L., Dussud, M., Metral, L., Ladier, A.-L. & Trilling, L. 2021. Towards a model assessing supply chain resilience strategies. Procedia CIRP, Volume 103, 14-19. https://doi.org/10.1016/j.procir.2021.10.001

Cambridge Dictionary. 2022. Supply chain. Accessed 20 May 2022. https://dictionary.cambridge.org/dictionary/english/supply-chain

Carmichael, T. & Hadzikadic, M. 2019 The Fundamentals of Complex Adaptive Systems. Accessed 6 June 2022. https://www.researchgate.net/publication/333780588_The_Fundamentals_of_Complex_Adaptive_Systems

Coaffee, J. 2019. Future proof: How to build resilience in an uncertain world. Yale University Press. Accessed 21 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=5844752

Continuity and Resilience Report 2022. The Business Continuity Institute. Accessed 15 October 2022. https://www.thebci.org/resource/bci-continuity---resilience-report-2022.html

Datta, P. 2017. Supply network resilience: a systematic literature review and future research. The International Journal of Logistics Management, 28 (4), 1387-1424. https://doi-org.nelli.laurea.fi/10.1108/IJLM-03-2016-0064

Dixit, V., Verma, P. & Tiwari, M.J. 2020. Assessment of pre and post-disaster supply chain resilience based on network structural parameters with CVaR as a risk measure. International Journal of Production Economics, Volume 227. https://doi.org/10.1016/j.ijpe.2020.107655

Faruquee, M., Paulraj, A. & Irawan, C.A. 2021. Strategic supplier relationships and supply chain resilience: Is digital transformation that precludes trust beneficial? International Journal of Operations & Production Management, 41 (7), 1192-1219. https://doi-org.nelli.laurea.fi/10.1108/IJOPM-10-2020-0702

Fayezi, S. & Ghaderi, H. 2022. What are the mechanisms through which inter-organizational relationships contribute to supply chain resilience? Asia Pacific Journal of Marketing and Logistics, 34 (1), 159-174. https://doi-org.nelli.laurea.fi/10.1108/APJML-06-2019-0363

Frederico, G.F., Kumar, V., Garza-Reyes, J.A., Kumar, A. & Agrawal, R. 2021. Impact of I4.0 technologies and their interoperability on performance: future pathways for supply chain resilience post-COVID-19. The International Journal of Logistics Management. https://doi-org.nelli.laurea.fi/10.1108/IJLM-03-2021-0181

Gioia, D. A., Corley, K. G., & Hamilton, A. L. 2013. Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. Organizational Research Methods, 16(1), 15–31. Accessed 20 December 2022. https://doi-org.nelli.laurea.fi/10.1177/1094428112452151

Golgeci, I. & Y. Ponomarov, S. 2013. Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. Supply Chain Management, 18 (6), 604-617. https://doi-org.nelli.laurea.fi/10.1108/SCM-10-2012-0331

Görner, S., Govindarajan, A., Panas, A., Greenberg, E., Kelkar, A., Kelleher, J., Kristensen, I., Liu, L., Padhi, A. & Silverman, Z. 2022. Something's coming: How US companies can build resilience, survive a downturn, and thrive in the next cycle. McKinsey & Company. Accessed 13 August 2022. https://www.mckinsey.com/business-functions/risk-and-resilience/our-insights/somethings-coming-how-us-companies-can-build-resilience-survive-a-downturn-and-thrive-in-the-next-cycle

Han, Y., Chong, W.K., & Li, D. 2020. A systematic literature review of the capabilities and performance metrics of supply chain resilience. International Journal of Production Research, 58 (15), 4541-4566. https://doi.org/10.1080/00207543.2020.1785034

Hohenstein, N-O., Feisel, E., Hartmann, E. & Giunipero L. 2015. Research on the phenomenon of supply chain resilience. International Journal of Physical Distribution & Logistics Management, 45 (1/2), 90-117. https://doi-org.nelli.laurea.fi/10.1108/IJPDLM-05-2013-0128

Hoopes, L. 2017. Prosilience: Building Your Resilience for a Turbulent World. E-book. Dara Press.

Hsuan, J., Skjøtt-Larsen, T., Kinra, A., & Kotzab, H. 2015. Managing the Global Supply Chain. Frederiksberg: Copenhagen Business School Press. Accessed 20 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=4186587

IMF 2022. IMF Managing Director Kristalina Georgieva Urges Key G20 Policy Actions to Safeguard the Recovery. Accessed 16 May 2022. https://www.imf.org/en/News/Articles/2022/02/18/pr2246-imf-managing-director-kristalina-georgieva-urges-key-policy-actions-to-safeguard-the-recovery

IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Accessed 21 May 2022. https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf

Ivanov, D. & Dolgui, A. 2021. A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. Production Planning & Control, 32 (9), 775-788. https://doi.org/10.1080/09537287.2020.1768450

Ivanov, D., Dolgui, A. & Sokolov, B. 2019. The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 57 (3), 829–846. https://doi.org/10.1080/00207543.2018.1488086

Juhila, K. 2022. Laadullisen tutkimuksen ominaispiireet. Teoksessa Jaana Vuori (ed.) Laadullisen tutkimuksen verkkokäsikirja. Tampere: Yhteiskuntatieteellinen tietoarkisto. Accessed 20 December 2022. https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/

Jokinen, A. 2022. Näkökulmat ja paradigmat. Teoksessa Jaana Vuori (ed.) Laadullisen tutkimuksen verkkokäsikirja. Tampere: Yhteiskuntatieteellinen tietoarkisto. Accessed 22 December 2022. https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus

Kalaiarasan, R., Olhager, J., Agrawal, T. K. & Wiktorsson, M. 2022. The ABCDE of supply chain visibility: A systematic literature review and framework. International Journal of Production Economics, Volume 248. https://doi.org/10.1016/j.ijpe.2022.108464

Kochan, C.G. & Nowicki, D.R. 2018, Supply chain resilience: a systematic literature review and typological framework. International Journal of Physical Distribution & Logistics Management, 48 (8), 842-865. https://doi-org.nelli.laurea.fi/10.1108/IJPDLM-02-2017-0099

Kuzior, A., Kettler K. & Rąb Ł. 2022. Great Resignation—Ethical, cultural, relational, and personal dimensions of generation Y and Z employees' engagement. Sustainability, 14 (11), 6764. https://doi.org/10.3390/su14116764

Li, X., Wu, Q., Holsapple, C.W. & Goldsby, T. 2017. An empirical examination of firm financial performance along dimensions of supply chain resilience. Management Research Review, 40 (3), 254-269. https://doi-org.nelli.laurea.fi/10.1108/MRR-02-2016-0030

Linkov, I. & Trump, B.D. 2019. Applying Resilience to Hybrid Threats: Integrating Infrastructural, Digital, and Social Systems. In: Linkov, I., Roslycky, L. & Trump, B.D. (eds.) Resilience and Hybrid Threats: Security and Integrity for the Digital World. NATO Science for Peace and Security Series D: Information and Communication Security – Vol. 55. IOS Press. Accessed 23 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=6006554

López-Castro, L.F. & Solano-Charris, E.L. 2021. Integrating Resilience and Sustainability Criteria in the Supply Chain Network Design. A Systematic Literature Review. Sustainability, 13 (19). https://doi.org/10.3390/su131910925

Lund, S., Manyika, J., Woetzel, J., Barriball, E., Krishnan, M., Alicke, K., Birshan, M., George, K., Smit, S., Swan, D. & Hutzler, K. 2020. Risk, resilience, and rebalancing in global value chains. McKinsey Global Institute. Accessed 16 May 2022. https://www.mckinsey.com/business-functions/operations/our-insights/risk-resilience-and-rebalancing-in-global-value-chains

Mandal, S. 2017. An empirical competence-capability model of supply chain resilience. International Journal of Disaster Resilience in the Built Environment, 8 (2), 190-208. https://doi-org.nelli.laurea.fi/10.1108/IJDRBE-02-2015-0003

McKinsey & Company. 2022. Digital twins: From one twin to the enterprise metaverse. Accessed 18 December 2022. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/digital-twins-from-one-twin-to-the-enterprise-metaverse

Merriam-Webster 2022. Resilience. Accessed 21 May 2022. https://www.merriam-webster.com/dictionary/resilience

Montecchi, M., Plangger, K. & West, D.C. 2021. Supply chain transparency: A bibliometric review and research agenda. International Journal of Production Economics, Volume 238. https://doi.org/10.1016/j.ijpe.2021.108152

Mubarik, M.S., Bontis, N., Mubarik, M. & Mahmood, T. 2022. Intellectual capital and supply chain resilience. Journal of Intellectual Capital, 23 (3), 713-738. https://doi-org.nelli.laurea.fi/10.1108/JIC-06-2020-0206

Nakano, K. 2021. Risk assessment for adaptation to climate change in the international supply chain. Journal of Cleaner Production, Volume 319. https://doi.org/10.1016/j.jclepro.2021.128785

Nieminen, M., Talja, H., Heikkilä, J-P., Airola, M., Viitanen, K. & Tuovinen, J. 2017. Muutosjoustavuus: Organisaation resilienssin tukeminen. Teknologian tutkimuskeskus VTT. Espoo. Accessed 20 May 2022. https://www.vttresearch.com/sites/default/files/pdf/technology/2017/T318.pdf

Nokia 2019. Nokia's digitalization of its 5G Oulu factory recognized by the World Economic Forum as an "Advanced 4th Industrial Revolution Lighthouse". Accessed 30 December 2022. https://www.nokia.com/about-us/news/releases/2019/07/03/nokias-digitalization-of-its-5g-oulu-factory-recognized-by-the-world-economic-forum-as-an-advanced-4th-industrial-revolution-lighthouse/

Nokia 2021a. Nokia Annual Report on Form F-20 2021. Accessed 16 May 2022. https://www.nokia.com/system/files/2022-03/nokia-ar21-20f_0.pdf

Nokia 2021b. Nokia to build new campus in Oulu. Accessed 30 December 2022. https://www.nokia.com/about-us/news/releases/2021/12/03/nokia-to-build-new-campus-in-oulu/

Pettit, T.J., Croxton, K.L. & Fiksel, J. 2013. Ensuring Supply Chain Resilience: Development and Implementation of an Assessment Tool. Journal of Business Logistics, 34 (1), 46-76. https://doi.org/10.1111/jbl.12009

Pettit, T.J., Fiksel, J., & Croxton, K.L. 2010. Ensuring Supply Chain Resilience: Development of a Conceptual Framework. Journal of Business Logistics, 31 (1), 1-21. https://doi.org/10.1002/j.2158-1592.2010.tb00125.x

Pimenta, M.L., Cezarino, L.O., Piato, E.L., Silva, C.H.P., Oliveira, B.G. & Liboni, L.B. 2022. Supply chain resilience in a Covid-19 scenario: Mapping capabilities in a systemic framework. Sustainable Production and Consumption, 29, 649-656. https://doi.org/10.1016/j.spc.2021.10.012

Ponis, S.T. & Koronis E. 2012. Supply chain resilience: Definition of concept and its formative elements. Journal of Applied Business Research, 28 (5), 921-929. Accessed 22 May 2022. https://www.proquest.com/scholarly-journals/supply-chain-resilience-definition-concept/docview/1048232253/se-2?accountid=12003

Ponomarov S.Y., Holcomb, M.C. 2009. Understanding the concept of supply chain resilience. International Journal of Logistics Management, 20 (1), 124-143. https://doi-org.nelli.laurea.fi/10.1108/09574090910954873

Pournader, M., Rotaru, K., Kach, A.P. & Razavi Hajiagha, S.H. 2016, An analytical model for system-wide and tier-specific assessment of resilience to supply chain risks. Supply Chain Management, 21 (5), 589-609. https://www-emerald-com.nelli.laurea.fi/insight/content/doi/10.1108/SCM-11-2015-0430/full/html

Rajesh, R. 2021. Optimal trade-offs in decision-making for sustainability and resilience in manufacturing supply chains. Journal of Cleaner Production, 313. https://doi.org/10.1016/j.jclepro.2021.127596

Saldana, J. 2011. Fundamentals of Qualitative Research, Oxford University Press. Accessed 20 December 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=665394

Sawik, T. 2011. Selection of supply portfolio under disruption risks. Omega, 39 (2), 194-208. https://doi.org/10.1016/j.omega.2010.06.007

Scholten, K. & Schilder, S. 2015. The role of collaboration in supply chain resilience. Supply Chain Management, 20 (4), 471-484. https://doi-org.nelli.laurea.fi/10.1108/SCM-11-2014-0386

Scholten, K., Sharkey Scott, P. & Fynes, B. 2019. Building routines for non-routine events: supply chain resilience learning mechanisms and their antecedents. Supply Chain Management, 24 (3), 430-442. https://doi-org.nelli.laurea.fi/10.1108/SCM-05-2018-0186

SFS-ISO 28002. 2011. Security management systems for the supply chain – Development of resilience in the supply chain – Requirements with guidance for use. Geneva: ISO copyright office.

SFS-ISO 31000. 2018. Risk management. Guidelines. Geneva: ISO copyright office.

Sheffi, Y. 2015. The Power of Resilience: How the Best Companies Manage the Unexpected. E-book. The MIT Press.

Shishodia, A., Sharma, R., Rajesh, R. & Munim, Z.H. 2021. Supply chain resilience: A review, conceptual framework and future research, The International Journal of Logistics Management. https://doi-org.nelli.laurea.fi/10.1108/IJLM-03-2021-0169

Simchi-Levi, D., Schmidt, W. & Wei, Y. 2014. From Superstorms to Factory Fires: Managing Unpredictable Supply-Chain Disruptions. Harvard Business Review. Accessed 14 June 2022. https://hbr.org/2014/01/from-superstorms-to-factory-fires-managing-unpredictable-supply-chain-disruptions

Simchi-Levi, D., Wang, H. & Wei, Y. 2018. Increasing Supply Chain Robustness through Process Flexibility and Inventory. Production and Operations Management, 27 (8), 1476-1491. https://doi.org/10.1111/poms.12887

Simons, H. 2009. Case Study Research in Practice, SAGE Publications. Accessed 20 December 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=743724

Southwick, S.M., Bonanno, G.A., Masten, A.S., Panter-Brick, C. & Yehuda, R. 2014. Resilience definitions, theory, and challenges: interdisciplinary perspectives. European Journal of Psychotraumatology, 5 (1), 25338. https://doi.org/10.3402/ejpt.v5.25338

Spieske, A. & Birkel, H. 2021. Improving supply chain resilience through industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic. Computers & Industrial Engineering, Volume 158. https://doi.org/10.1016/j.cie.2021.107452

Suryawanshi, P. & Dutta, P. 2021. Optimization models for supply chains under risk, uncertainty, and resilience: A state-of-the-art review and future research directions. Transportation Research Part E: Logistics and Transportation Review, 157. https://doi.org/10.1016/j.tre.2021.102553

Taylor, S. J., Bogdan, R. & DeVault, M. 2015. Introduction to Qualitative Research Methods. John Wiley & Sons, Incorporated. Accessed 31 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=4038514

The Global Risks Report 2019. World Economic Forum. Accessed 16 May 2022. http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

The Global Risks Report 2020. World Economic Forum. Accessed 16 May 2022. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf

The Global Risks Report 2021. World Economic Forum. Access 16 May 2022. http://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf

The Global Risks Report 2022. World Economic Forum. Accessed 16 May 2022. https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf

The International Disaster Database. 2022. Accessed 16 May 2022. https://www.emdat.be/

Tukamuhabwa, B.R, Stevenson, M., Busby, J. & Zorzini, M. 2015. Supply chain resilience: definition, review and theoretical foundations for further study. International Journal of Production Research, 53 (18), 5592-5623. https://doi.org/10.1080/00207543.2015.1037934

UNDDR 2022. Terminology: Resilience. Accessed 21 May 2022. https://www.undrr.org/terminology/resilience

WHO 2022. 14.9 million excess deaths associated with the COVID-19 pandemic in 2020 and 2021. Accessed May 16 2022. https://www.who.int/news/item/05-05-2022-14.9-million-excess-deaths-were-associated-with-the-covid-19-pandemic-in-2020-and-2021

Yin, R. K. 2015. Qualitative Research from Start to Finish (2nd Edition). Guilford Publications. Accessed 31 May 2022. https://ebookcentral.proquest.com/lib/Laurea/detail.action?docID=2008479

Yuan, Y. & Li, W. 2022. The effects of supply chain risk information processing capability and supply chain finance on supply chain resilience: a moderated and mediated model. Journal of Enterprise Information Management. https://doi-org.nelli.laurea.fi/10.1108/JEIM-09-2021-0383

Zak, Dan. 2021. 'Nothing ever ends': Sorting through Rumsfeld's known and unknowns. The Washington Post. Accessed 11 February 2023. https://www.washingtonpost.com/lifestyle/style/rumsfeld-dead-words-known-unknowns/2021/07/01/831175c2-d9df-11eb-bb9e-70fda8c37057_story.html

Zouari, D., Ruel, S. & Viale, L. 2021. Does digitalising the supply chain contribute to its resilience? International Journal of Physical Distribution & Logistics Management, 51 (2), 149-180. https://doi-org.nelli.laurea.fi/10.1108/IJPDLM-01-2020-0038

Unpublished

Celebrating one year of our #MNSCstrategy. 2022. Internal presentation.

Information classification and handling SOP. 2021. Standard operating procedure.

MN COO SC All Hands May. 2022. Internal presentation.

MN Supply Chain Strategy. 2022. Internal presentation.

Figures

Tables

Appendices

Appendix 1: Supply chain resilience conceptual framework (modified from Ali, Mahfouz & Arisha 2017, 26-28)

Concept: SUPPLY CHAIN RESILIENCE (1/3)				
Phase: Before disruption				
Strategy: Proactive strategy				
Capability: Ability to anticipate				
Elements: Situational awareness	Robustness	Knowledge mgmt. (pre-event)	Security	Visibility
Managerial practices: Continuity planning; risk avoidance and containment; risk control / transfer / share; sensing and interpreting events; mapping supply chain vulnerabilities; warning strategies	Anticipation / preparedness to changes; complexity; decentralization; density; node / location criticality; product design; product flow; segmentation; supply chain / infrastructure configuration; supply chain network design; supply base strategy	Board-level leadership; education and training; inter-organizational learning; risk awareness; risk management department; supply chain drills, simulations, and exercises; supply chain risk mgmt. and resilience culture; supply chain understanding	Cooperative strategies with supply chain partners; counterfeit countermeasures; cyber-security; freight / physical security; layered defenses; public-private partnerships; security culture	Connectivity; information sharing; IT capabilities; monitoring performance (KPI); transparency through integrated systems
Result: COMPETITIVE ADVANTAGE				

Concept: SUPPLY CHAIN RESILIENCE 2/3			
Phase: During disruption			
Strategy: Concurrent strategy			
Capability: Ability to adapt		Ability to respond	
Elements: Flexibility	Redundancy	Collaboration	Agility
Managerial practices: Flexible manufacturing processes and resources; flexible order fulfillment; flexible pricing via responsive pricing; flexible product via postponement; flexible supply via multiple suppliers; flexible transportation modes	Emergency backup / storage facilities; excess capacity in production / transportation / resources; low-capacity utilization; multiple suppliers; safety stock; strategic inventory	Collaborative planning; cooperation with competitors; coordination; information sharing; supply chain intelligence	Responsiveness; speed, velocity, and acceleration
Result: COMPETITIVE ADVANTAGE			

<table>
<tr><td colspan="4">Concept: SUPPLY CHAIN RESILIENCE (3/3)</td></tr>
<tr><td colspan="4">Phase: After disruption</td></tr>
<tr><td colspan="4">Strategy: Reactive strategy</td></tr>
<tr><td colspan="2">Capability: Ability to recover</td><td colspan="2">Ability to learn</td></tr>
<tr><td>Elements: Contingency planning</td><td>Market position</td><td>Knowledge mgmt. (post-event)</td><td>Social capital</td></tr>
<tr><td>Managerial practices: Recovery and restoration plans; resource reconfiguration; scenario analysis; supply chain reconfiguration; time to market</td><td>Adaptability; customer communications; customer relationships; efficiency; financial strength; market share; strategic alignment</td><td>Becoming a learning organization; cost / benefits knowledge; education and training; innovativeness in contingency planning and management; looking for opportunities; post-disruption feedback</td><td>Co-creation processes; inter-organizational relationships; relational competence; trust</td></tr>
<tr><td colspan="4">Result: COMPETITIVE ADVANTAGE</td></tr>
</table>

Appendix 2: Full coding table for the supply chain resilience factors and development (see also Figure 5 for a summary)

1st-order coding	2nd-order coding	3rd-order coding
1. The company's mindset is no longer about cost efficiency. It is about resilience and efficiency, the change that needed to happen. 2. I think the enabler is Nokia's culture, which has helped us sail through this difficult period. 3. Our gang is committed, and it takes a long day, night, and weekend to resolve the matter. And then we are often quite agile in making decisions, and we try to fix the situation.	Culture and mindset (+)	People
4. Always after crises, it has been recognized that we should review what has been learned, but somehow, we need to improve at the practical level in the implementation. 5. We are very strong in reactive mode. When we have an earthquake or fire, or it is a tsunami, we are very fast. 6. We are good when it hits the fan. In hindsight, we should have started certain things a lot earlier, but since that experience has told us that this has always been taken care of, it slightly biased our thinking. The ability to prepare in advance for crises could have been better.	Culture and mindset (-)	People
7. The leadership was heavily committed and engaged in influencing the suppliers. So that is their magic and charisma, and I give all respect to them. What magic they did, I do not understand. 8. The most vital part is that we have massive support from the MN's Chief Operating Officer and President. 9. I think our enablers are our executives. They have done an excellent job of ensuring that all the pieces are in place.	Leadership (+)	People
10. The challenge also comes from the higher you go, the less understanding there is of practical matters. Things start to be black and white at the upper level. 11. Sometimes, the management level thinks it is only one organization's problem. The supplier interface is, for example, the sourcing's responsibility. Sourcing's responsibility is to ensure that resilience is in place and that suppliers support us. If this does not	Leadership (-)	People

1st-order coding	2nd-order coding	3rd-order coding
happen, then it is the sourcing's fault, although there may be many things related to product and project decisions that affect the result. 12. Regardless of the situation, we should dig leadership out of our pockets, lead the team to that solution, and motivate them. Unfortunately, I have witnessed in meetings that leaders try to find those who are guilty instead of inspiring people.		
13. Many challenges have been seen, from which lessons have been learned. Experience and level of competence are good. 14. We have a house full of top experts. Even though we are resource-limited, we also have people who know how to separate the coconuts from the peanuts and make world-class plans. Moreover, of course, they have a lot of experience. 15. The overall skill sets or knowledge to tackle supply chain-related crises does exist in our people. We are hiring pretty good people.	Competencies (+)	People
16. It is not just the development of tools but also the ability to use them. With our average ability to analyze data, there is still much to improve. 17. When resilience is talked about, the only thing which matters is execution. In the end, if you cannot do it, then even a good plan does not matter, and that is where we had this resource pool challenge. So general project and resource management skills, the way you manage the workload. 18. Because we have never asked them to, many people seem to need help to show the organization that they can think outside the box, which is required for these extreme situations.	Competencies (-)	People
19. The first topic that would come to mind is our diverse multinational multi-country setup. Our workforce is exceptionally diversified, so that is certainly an enabler.	Diversity (+)	People
20. We are running more and more key projects simultaneously with the same people. We have very few people to support these projects, and they are getting overwhelmed.	Resourcing (-)	People

1st-order coding	2nd-order coding	3rd-order coding
21. The people required to execute need more resources because they are being pulled from their day-to-day jobs and are overloaded. 22. We have many initiatives running at the same time.		
23. Now, with the new structure where we have Supply Chain and Sourcing inside MN, I think we instantly start to see positive changes. 24. With these latest crises, COVID, and semiconductor shortages, it would have been impossible to manage if we had been a centralized function. It has felt like we are all in the same boat, which has been quite decisive in addressing these crises. Trust and cooperation have been different. Now that we have been part of MN, that is what got us to operate together. 25. Now is the first time all necessary parties are at the same table. When we went to this business group-driven organizational model, this was the fundamental enabler. It is now visible that R&D and the supply chain are closer. We have a common interest.	Organizational change (+)	Collaboration
26. There is a little bit of a lack of that sync now. We are all put into separate divisions, and there needs to be a willingness to work and do things together. 27. When our org change happened, we sliced and diced so heavily that the supply chain, which is supposed to be a horizontal organization across the various business groups, was compartmentalized, which means that wherever synergies could have been found were lost. 28. I was not thrilled about the split. I think MN works out of its playbook. I see my peers, and they work differently than MN does.	Organizational change (-)	Collaboration
29. I think that we are still too much silo driven. From an organizational perspective, we have on paper all the elements to build these capabilities, but the mode of operation of these organizations is silo driven. We have fragmentation in the overall objectives, and building an end-to-end view is challenging. 30. We are heavily focused on our respective roles. We need to look at who our internal customer is. This partnering within the teams needs to be improved.	Organizational silos (-)	Collaboration

1st-order coding	2nd-order coding	3rd-order coding
31. In desperate times, people easily slip back into what is proven to be a winning setup, which is the silos.		
32. Every site has a business continuity plan. We have that for manufacturing locations. Our suppliers have it for their manufacturing locations. 33. We have been in a triple-fault or quadruple-fault scenario where you have a trade war, COVID, Russia war, and semiconductor shortages. The fact that we have succeeded is a great testament to what we can do—this is an excellent testament to the level of business continuity we already have. 34. The company is very good at business continuity planning.	Planning (+)	Business continuity
35. We can achieve the goals. We have a strategy. We have a vision. We have a plan, and it is time. 36. We have a pretty good and comprehensive bunch of great activities. 37. You have seen many barriers to being resilient, but most of these are being addressed in the latest version of the supply chain strategy.	Planning (+)	Strategy
38. It was tough to manage for these last two years because the reality is that due to the pandemic, the close-ups, and due to our strategy of having minimal stocks, we were impacted. 39. What needs to be considered is people focus. The world changes and demands new things from our people. We also must make sure that we also change our people strategy. How can we ensure people can openly and innovatively think about the future? What do we do to create new information for people with this ability to adapt and go along with this? Here we are still weak. 40. One such thing that might have needed to be added is the customer and market interface. When we think about the fact that we have very different types of markets and the dynamics are very different, how do we manage them, such as customer expectations and so on?	Gaps (-)	Strategy
41. Most of our mitigation plans will take at least a year or two before resilience starts to fortify.	Execution (-)	Strategy

1st-order coding	2nd-order coding	3rd-order coding
42. New projects are being set up. However, introducing such big tools takes a long time. We will see the benefits after two years or something. 43. But there is one thing that makes it difficult, or what needs to be considered better, and that is the execution of the strategy.		
44. We have put all the money into prioritizing the road map improvement because we have been behind most of our competitors in the past, and we are just catching up. Therefore, we did not have enough to build resiliency faster. 45. Preparedness also has a price tag. We have been struggling with the turnaround, so there has been a limited amount of resources to be invested in resilience. 46. It is always a discussion about how much money you invest in the resilience and flexibility of supply. It is a difficult decision and requires a lot of money to build a fully resilient supply chain.	Cost (-)	Strategy
47. We learned from that triple fault or quadruple fault scenario experience that we needed more dual sources. 48. If we could standardize more on form factors, we would get a better chance to tier two localization because it would be higher volumes. We would get easier manufacturing transfers from site to site because it is already enabled in multiple regions. And we are getting a better price and lower costs. 49. We need to be careful with regionalization because the earlier approach ensured that you could balance inventory and react to the markets quickly. However, the regionalization we are now talking about is because of the political and geopolitical dynamics. While doing so, we must have a very thought-out inventory cross-balancing approach. Otherwise, we may create inventory pools in the wrong bucket.	Dual sourcing and regionalization (-)	Strategy
50. It would be good to discuss what is essential in the end because the program's goals in the program phase override everything. On the other hand, the program's goals, when realized, may define the supply chain's opportunities to reach its own goals. A	Key performance indicators (-)	Measurement

1st-order coding	2nd-order coding	3rd-order coding
few KPIs could be challenged to see where the worst conflicts are. 51. We put quite a lot of effort into thinking about and following those metrics, but quite a lot of those are still looking back, and then we are again in this kind of reactive mode versus being able to develop. We could develop metrics so that they can predict what is coming. 52. The end-to-end view needs to be added. What I see is that everybody has good KPIs. The warehousing, manufacturing, transportation, and customer teams have good KPIs, but who looks after the holistic view?		
53. We should go much deeper on the partnership side. Specifically, to be transparent in the supplier's direction. If it is known that a supplier is essential, we must understand their network and supply chain and recognize the risks and what can be done together. Because if they fail, we fail. 54. But our feeling is that we act like two entities or organizations. As Market Operation, we need more visibility from the supply chain, and the supply chain needs to share all the information with us. 55. It is making things more transparent than we have today. Today we do not have processes or systems where you have, by the push of a button, an overview of your real exposure. It is more the transparency and the visibility of what people should have supported by the technology.	Transparency and visibility (-)	Supply chain
56. When it comes to the customer view, we are not delivering on time 57. If you have a specific problem or escalation for a particular module, you need to know to whom you should go. Everyone is telling you this is not with me. So, it takes a long time to escalate instead of going straight to the right contact. 58. I listen to our supply chain and customers, and the customer’s voice is saying that we, as Nokia, do not have the speed of our competitors.	Delivery time (-)	Supply chain
59. There is more that we can do, but there is also that balance that we must be careful of because of Nokia's commitment to sustainability. Our resilience	Sustainability (-)	Supply chain

1st-order coding	2nd-order coding	3rd-order coding
sometimes pushes and pulls against sustainability, so that is where the gap lies.		
60. We had early warnings and factual information available. Still, we need a systematic approach to convert this information as a baseline for decision-making to take proactive decisions. 61. We need to do something about the processes and how we operate because, in this war room mode we are now, the whole process is not working anymore. There is much manual work because many process elements need to be fixed. We are still in exception management mode and must get to a new normal process. 62. The processes need to be updated. We have made minimal changes and minimal progress on, for instance, digitization.	Approach and process (-)	Supply chain
63. We have a very high complexity because of the nature of our business. We have hundreds of suppliers and thousands of individual parts that need to be purchased at the right time in the right quantities, in the right factories in the right composition. 64. The complexity of products has significantly increased. We have ten times more products, and the number of customer-dominant products has significantly increased. 65. When we have gone to 5G, the number of radio variants has exploded. This has made this environment complex.	Complexity (-)	Products
66. Much data is being analyzed, but many times in a manual way. We need to keep investing in automation. 67. To get the power of data analytics, we have got to do a better job of defining and stabilizing our data and then use computing power to learn to see the future. That is the biggest challenge we have. 68. To build products for hundreds of customers in this very constrained situation, we need more digitalization. We have fallen behind in the last few years because we did not have a budget because of the turnaround. This is something we are suffering still today.	Automation and digitalization (-)	Technology

1st-order coding	2nd-order coding	3rd-order coding
69. What can you do from scenario planning if this event happens? I get on these calls, and customers ask for stuff like that. We do not have that capability now because it would be a manually intensive effort, so we need more capacity. How do you create the ability to do that kind of work more in an automated fashion so that it frees up time to do some scenario planning and stuff like that? 70. We need something that analyses our product portfolio. We need something that says here is the known demand, and what is our probability that we meet that demand? And then, if the demand doubles, what is our likelihood of meeting that? Moreover, what risks are we exposed to if the demand is cut in half? So, there needs to be something built into the data analytics that tells us do we have confidence: can we do what we plan to do? If plans change, what is the impact, and how do we respond to that? 71. If we go to the simulation of different scenarios to think about which products to redesign, many parameters affect it, and those are constantly changing. Suddenly, a new customer brings additional volume, and another one disappears. Then one component crisis is solved, and another pops up. It is a constant change and is now a huge manual job. We are often a step behind, and the situation has already changed when we have decided to do something. Moreover, it can be that we do the wrong things, or it can be that something is overlooked, which complicates the situation. A digital twin is undoubtedly a good exercise and aims at the right things.	Scenarios (-)	Technology