State of the Art of Purchasing 2023

Purchasing Management Master Course University of Twente

Babette de Brouwer, Carmen Cijffers, Max Derwig, Danielle Ehizibue,
Sten Eijkholt, Stef Fisscher, Ruben Gerhardus, Mark de Goeij,
Liz Greven, Wolf Jansen, Stijn Korfage, Stef Kosters,
Nick van Lambalgen, Pim Langeveld, Timo Looms, Max Mastebroek,
Carlijn Meijerink, Eva Nelissen, Daan Pierik, Twan de Roode,
Jimmy van Santen, Renee Seuntiëns, Eva Stoica, Hanna Sturm,
Oscar Viladrich Beiroa

Klaas Stek, editor

UNIVERSITY OF TWENTE.

Foreword

State of the Art of Purchasing 2023 is written by University of Twente master students in the Purchasing Management course 2023-2024, designed for Industrial Engineering and Management, Business Administration and Health Science students. The course introduces the discipline of Purchasing and Supply (Chain) Management (PSM) to master students who missed PSM classes during their Bachelor studies.

The learning objectives of Purchasing Management course are built upon the distinct competencies (knowledge, skills and traits) of successful PSM practitioners derived from the extensive European Survey on Purchasing Skills of the Project PERFECT (www.project-perfect.eu) and the University of Twente. About 600 purchasing professionals filled out the survey. The outcomes of the project and the survey are twofold: 1) an understanding of what skills, traits and knowledge fields are associated with successful purchasers in companies and organisations in Europe and 2) what didactics are preferable to teach these skills/knowledge fields to academic (Master) students.

The reason for the project PERFECT (and hence of the master course Purchasing Management) is that the discipline of PSM is gaining strategic importance, not only in industrial companies but also in service organisations and the public sector. Typically, production organisations purchase over 60-80 per cent of their turnover, and public procurement counts for 15 per cent of GDP, i.e. € 2 trillion annually in the EU. In the last decade, PSM's importance is therefore increased as a strategic discipline in the field.

In organisations, the PSM function is the interface between the operations and suppliers (and supply chain), constantly focusing on the final customer or end-user. Due to the societal-demographic, environmental and technological changes, PSM is facing more significant issues such as sustainable procurement, ethical and socially responsible buying, and handling machine-to-machine communication in the 'Industry 4.0 ' process.

In the course Purchasing Management, the aim is to develop up-to-date 'success' skills, traits and knowledge, to develop a deeper understanding of what tactical and strategic aspects are involved in PSM and how these aspects can be analysed and managed. The research project PERFECT shows that PSM professionals need strong inter- and intrapersonal skills to perform the hard-professional skills in the PSM or any other profession. Literature states that a labour contract with an employee is more likely to end because of a lack of soft skills than a lack of hard skills.

The didactics of this course are student-centred: PSM professionals were invited to perform workshops on the content and personal development, and the further lectures are mainly built upon student participation. Also, 'normal', classical, instructive lectures were part of the course. The course has a study load of 5 ECTS, i.e. 140 hours of study, including 25 hours of lectures, workshops and case evaluations.

To access the PSM content and theories, the students were encouraged to work in teams, communicate in a cross-cultural setting, consider calculated risk, think out-of-the-box, and find creative, inventive, novel, and valuable solutions to complex problems. The aim is to develop individual traits that are indispensable for a future career as a professional. For the tendering cases, each student group, consisting of two to four students, worked out a combined strategic-tactical case in industrial purchasing (Thales and LimeYellow) and public procurement (procurement departments of the Province of Overijssel, UTwente, Ministry of Defence and consultant AevesBenefit).

This book resulted from the scientific project that was part of the course. Students were grouped differently for the case and assigned to one of the twelve chapter subjects. The 25 students in the nine groups subsequently digested about 330 journal articles, book chapters, and reports in the chapters of this book. Each group was entitled to have at least two meetings of 30 minutes with the lecturer to discuss the progress of the book chapter.

The co-authors of State of the Art of Purchasing 2023 take the reader through the purchasing and supply 2021 landscape via Part 1 – Sustainable Purchasing and Supply Chain Management focuses on Sustainable supply chains – what has been achieved and where to go?; Biodiversity management – a supply chain practive view; Purchasing competencies for sustainable sourcing; Sustainable supply chain laws and due diligence; Inclusive, social sustainability in purchasing and supply management. Buyer-Supplier Relationships.

Part 2 – Industry 4.0, the Internet of Things, Procurement 4.0, Artificial Intelligence elaborates AI, Big Data Analytics and Machine Learning in Purchasing and Supply Chain Management. Part 3 – Geopolitics, Reshoring and Resilient supply chains focuses on Reshoring in the supply chain, Geopolitical influence on international supply chains, Supply chain resilience, and anticipating disruptions and natural disasters. Due to regrouping the students in the first week of the course, Chapter 6 has been discarded.

Communication (oral and written) and presentation skills are essential for graduates. However, these skills are not innate. Writing is an art that has to be practised. In the course *Situation, Complication, Question, and Answer* (*SCQA*) Menti framework is applied to frame and define the problems in solving the complex case and writing the chapter. The framework structured the students' ways of thinking and working. Over six to eight weeks, the students' writing skills showed a steep increase, including proper citing using a reference application (EndNote).

The students' writing skills are improved, and their understanding of the implications of strategic PSM and the distinctions between private purchasing and public procurement is deepened. Moreover, as the coordinator and lecturer in the course, I have observed a significant improvement in intrapersonal character traits, like inventiveness and strategic thinking, highly appreciated by employers.

This group of students demonstrated a high willingness to learn, aimed at the course's case-driven character. The case formed the context of most of the lecturing material. It means the student will not truly learn without being willing to learn. The lecturer's task is first to make the student think before there is a possibility for the proper transfer of knowledge and training skills and traits.

My gratitude goes out to all the students who cooperated in the UTwente course Purchasing Management in September and October 2023.

Hengelo, October 2023

Dr. Klaas Stek

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Chapter 1 - Sustainable supply chains – What has been achieved, and where to go?

Danielle Ehizibue, Carlijn Meijerink and Hanna Sturm

Summary

Over the past decade, supply chains have extended geographically and become less sustainable due to globalisation. Consequently, environmental regulations and laws have been implemented, resulting in remarkable interest and awareness in sustainable supply chains. This chapter examines the evolution of sustainable supply chains and the recent measures that have been implemented to make supply chains environmentally sustainable. Moreover, an outlook for the future of sustainable supply chains is given. Emerging developments and technologies such as reshoring, blockchain and circular economy will be discussed in this chapter.

1.1 Introduction

Manufacturing production has been transformed in the past decades. Supply chains grew graphically longer, resulting in global supply chains (Free & Hecimovic, 2021). Managing and controlling global supply chains is challenging since overall transparency is low (Saberi, Kouhizadeh, Sarkis, & Shen, 2019). Due to globalisation, raw materials and components are shipped worldwide before forming the final product. Final products are shipped via supply chains to reach the end users (Kandil, Battaïa, & Hammami, 2020).

In the past two centuries, the biosphere has warmed by one degree Celsius since industrialisation. Until 2100, the temperature will rise by two to five degrees. This is evident unless the greenhouse gas emissions are reduced (Harvey et al., 2023). The temperature rise will lead to biodiversity loss, health impacts, ecosystem changes and many more unthinkable events. Therefore, sustainability has been acknowledged as increasingly urgent in the past decades (Wieland, 2021).

As production centres, Asian countries have become essential in many global supply chains (Glushkova, Lomakina, & Sakulyeva, 2019). The production industry produces the most emissions. Therefore, sustainability has become a supply chain issue (Khattak, Ahmad, Haq, Shaofu, & Hang, 2022). Due to globalisation, production has been offshored to Asian countries and therefore also the emission of greenhouse gasses.

Global supply chains and sustainability are complex concepts to combine. Supply chains that are graphically longer were not designed with the impact on the planet in mind. The focus was mainly on where the cheapest production was possible. This is all included in the sourcing strategy: do we make it ourselves or buy it from a supplier? The main question is whether we have the resources to do it without considering environmental indicators. If a supplier is used, there is also the decision to use a local supplier or to offshore it to another country. This last option is often the inexpensive option as this is most likely closer to the needed resources and

has cheaper labour. Offshoring is also only focused on the costs for the company while paying no attention to the possible impacts it could have. At the same time, sustainability is less concerned with production costs and focuses on the whole effect on the planet. Therefore, global supply chains and sustainability do not go together as the supply chains are structured nowadays.

The European Parliament is working hard on the Corporate Sustainability Due Diligence Directive. This new law obligates companies to take responsibility for human rights abuses and environmental harm throughout the supply chain. This would increase transparency for companies and their suppliers. The introduction of this law shows that even the government feels the need to change the traditional way of supply chains.

This chapter reviews the environmental side of the sustainability of supply chains and gives an outlook for the future. First, the evolution of supply chains and recent achievements are enlightened. Then, the current developments and technologies like transportation, reshoring, blockchain and circular economy are discussed. Lastly, an outlook for the future is given.

1.2 What has been achieved, and where to go?

The databases Scopus and Google Scholar were used to perform the literature review. The following search strings were used: "sustainable supply chain" AND globalisation, sustainable AND supply AND chain AND performance (Year 2022-2023). These resulted in about 1500 sources. From this, relevant sources were selected. These sources provided information on evolution, the challenges, and the introduction. This section, the recent achievements are stated and how these came to be.

1.2.1 Evolution of sustainable supply chains

Supply chains have become highly complex due to globalisation and increased international trade (A. Ashby, Leat, & Hudson-Smith, 2012). Globalisation created opportunities for companies to move their logistics and transportation activities to countries with lower labour costs (Abbasi & Nilsson, 2012a). This led to economic advantages for companies in the global supply chain. However, it also caused negative impacts on the environment (Rajeev, Pati, Padhi, & Govindan, 2017). Therefore, the interest and importance of sustainability in supply chains have increased over the recent decades.

The concept of sustainability development was first introduced in the Brundtland Report by the World Commission on Environment and Development (WCED) in 1987 (Barnaby, 1987; Rajeev et al., 2017). Moreover, in 1997, the Kyoto Protocol was adopted to reduce greenhouse gas emissions and alert on climate change issues (BÖHringer, 2003). These introductions have sparked increasing interest and awareness among businesses and researchers in applying sustainability across various fields (Alison Ashby, Leat, & Hudson Smith, 2012) (Rajeev et al., 2017).

Over the years, strict environmental regulations and laws have been put into place, pressuring companies in developed countries to implement sustainable practices (Rajeev et al., 2017). Nevertheless, due to strict environmental laws, companies started to outsource parts of their

business to underdeveloped countries without environmental laws. Consequently, the Green Supply Chain Management (GSCM) initiative was established (Rajeev et al., 2017). According to (S. K. Srivastava, 2007), GSCM can be defined as 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'. Hence, reducing the environmental impact within a supply chain is the primary purpose of GSCM.

1.2.2 Recent achievements

All stakeholders within a supply chain ought to acquire knowledge and be aware of the environmental impact across their entire chain (O'Rourke, 2014). However, the precise measurement of the environmental impact of sustainability within a supply chain is a challenging concept. Sustainable measurement tools, such as the Life Cycle Assessment (LCA) and product carbon footprinting, have intensively been used by firms (França et al., 2021). The LCA is a multi-disciplinary approach and tool that quantifies a supply chain's environmental performance. Every stage of the life cycle of a product generates an impact on the environment.

Hence, the LCA analyses the entire environmental impact of a product and its processes, from the initial sourcing of raw materials to waste management (Lippiatt, 2013). Four key phases are involved in the execution of an LCA (Horne, Grant, & Verghese, 2009). First, the goal and scope of the LCA analysis need to be defined. Second, an inventory analysis needs to be performed, involving data collection and calculation to quantify a product's or process's inputs and outputs across its entire lifecycle. The third phase is impact assessment. During this phase, the potential environmental impacts associated with the identified inputs and outputs of the product or process are examined (e.g., resource depletion or global warming).

In the last phase, the inventory analysis and impact assessment findings are interpreted to guide and inform decision-makers regarding the product's or process's environmental performance across the lifecycle. However, the LCA has its limitations. For example, data uncertainty could occur in the inventory and impact analyses, negatively impacting decision-making. Additionally, the collection of inventory data can be very time-consuming since there is a need for more readily available inventory and impact data, particularly outside Europe (Curran, 2014). In Europe, the European Commission's Platform on Life database is a publicly available database that allows firms to collect, publish and standardise data for the LCA easily.

Another recent practice is that many companies are mapping and publishing their supply chain (MacCarthy, Ahmed, & Demirel, 2022) (O'rourke, 2014). Supply chain mapping is collecting, analysing, and visualising information concerning all suppliers (from first to lower tiers) and material flows in the supply chain, resulting in a supply chain map (MacCarthy et al., 2022). Supply chain mapping provides decision-makers extensive knowledge about their supply chain, essential for proper sustainable management and planning. Besides, unexpected disruptions could negatively affect the supply chain. Hence, by developing supply chain maps, firms can quickly and easily gain visibility to monitor and minimise potential risks (MacCarthy et al., 2022). For instance, (van den Brink, Kleijn, Sprecher, & Tukker, 2020) created a supply chain map of the cobalt supply chain to assess its vulnerability and identify potential supply risks.

However, the literature shows several challenges associated with developing supply chain maps. It can be expensive, time-consuming, and heavy on resources. Additionally, there is a lack of specific guidelines for conducting the mapping process (MacCarthy et al., 2022).

Finally, (Abbasi & Nilsson, 2012b) examined themes and challenges for environmentally sustainable supply chains. The authors stated that financial cost is the greatest obstacle to achieving sustainability in supply chains, as there is a conflict between minimising environmental impact in the supply chain and increasing cost. Hence, in the next section, we will investigate several approaches which can be used to enhance sustainability in supply chains and reduce costs in the future.

1.3 Sustainable supply chains: the future

As awareness of the importance of sustainable supply chains is increasing, the future challenge remains on creating a fully sustainable supply chain, or that may be an imaginary goal. This section discusses different outlooks on the future of supply chains, focusing on environmental sustainability. First, a broader managerial perspective is regarded. Afterwards, approaches to improving sustainability regarding transportation, using blockchain and the transition to circular supply chains are discussed.

1.3.1 A shift in supply chain management

The perspective of supply chains in terms of sustainability should be reconsidered. As argued by (Wieland, 2021) argued that the supply chain has often been seen as a separate entity, while it is a complex web of layers and structures that all influence each other. A prominent example of this is COVID-19, as a factor outside its scope disrupted all supply chains. Wieland (2021) describes the system as a panarchy with linkages. Based on Field Gunderson (2002), the panarchy describes the complex relationships between the supply chain, political-economic, and planetary levels. The infinity signs indicate the flow of change, from slow growth to the possibility of a quick fall. The model shows that the stability of the three levels is an illusion since they are constantly changing, influencing the levels around them as well (Wieland, 2021). Future supply chain management should account for all perspectives to ensure the possibility of a truly sustainable supply chain.

Being aware of the environmental effects of the supply chain and integrating methods to reduce the impact can be described as green supply chain management (GSCM). In the paper of (Tseng, Islam, Karia, Fauzi, & Afrin, 2019), a literature review on GSCM is done, and several points stand out. First, collaboration with all parties, such as customers, suppliers, and logistics service providers, is necessary. With a reliable partnership, information about emissions can be shared, as well as knowledge to improve the sustainability of the supply chain. Secondly, the effect of drivers and barriers is mentioned. Many factors can stimulate GSCM, such as regulatory pressure or discourage it, such as risks and costs. To have efficient GSCM, the drivers should outweigh the barriers. Lastly, it is mentioned that most of the focus of environmental improvement is targeted towards large firms. While these are responsible for significant emissions, the impact of smaller firms should not be forgotten (Tseng et al., 2019). Current and future managers should consider the aspects of GSCM.

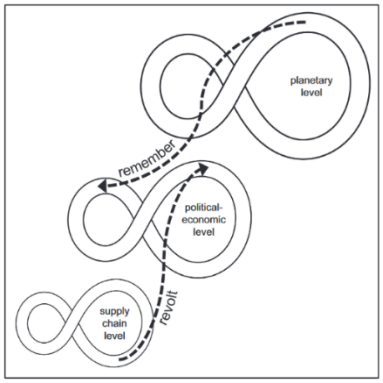

Figure 1 - Panarchy by Gunderson & Holling

1.3.2 Transportation

Transportation is essential to a supply chain; materials or products must be moved from the source to the processing location and afterwards to the customer. Currently, most goods are moved via road transport, a very polluting transportation mode (Ritchie, 2020) and responsible for nearly one-fifth of the total EU greenhouse emissions (Commision, 2019). To reduce this contribution, action can be taken to reduce the amount of road transport or road transport itself can be made more sustainable.

		To: Onshore	
		In-House	Outsourced
From: Offshore	In-House	In-House Reshoring	Reshoring for Outsourcing
	Outsourced	Reshoring for Insourcing	Outsourced Reshoring

Figuur 1 Categories of Reshoring

The first method to reduce the amount of road transport is a combination of freight consolidation and model split transport. With freight consolidation, a horizontal collaboration between companies is meant to arrange transport, resulting in fuller and fewer trucks. In addition to this, modal split transport can be used, which focuses on other transport modes such as trains. This approach could be applied in practice by, for example, moving a base-stock inventory level by train and using trucks to supply periodic demand. No extra costs are made with such a method, while truck usage is decreased (De Moor, Creemers, & Boute, 2023). The positive effect of horizontal collaboration is confirmed through (Ouhader & El kyal, 2023). By focusing on a specific case, shipper collaboration, they created a model based on the general vehicle and location routing problems. While good optimisation of both cost and emissions turned out to be conflicting objectives, they showed that the model could positively affect both (Ouhader & El kyal, 2023). Another approach to reducing transportation is the use of reshoring.

Reshoring can be interpreted in the ways demonstrated in Figure 2. Nearshoring is the placement of manufacturing close to the company. Reshoring is the relocation of manufacturing by nearshoring it to the company. As an effect, fewer kilometres must be travelled for the same production process. Besides improved transparency, more jobs close by and fewer risks are also effects of reshoring (Fernández-Miguel et al., 2022). Lastly, standardised packaging can also reduce the number of kilometres travelled. In addition to the freight consolidation approach, standardised packaging increases the efficiency of trucks by utilising the space available as much as possible (Dubisz, Golinska-Dawson, & Kolinski, 2023). An obstacle is the redesign of packages, but since packaging should be completely reusable, biodegradable and based on a bio-based plastic solution by 2023 (Tua, 2019), this already leads to an inevitable re-design of most packaging.

Next to the above reduction methods, there are also several approaches to eliminate the emissions from road transport as an alternative to fossil fuels, electricity or hydrogen can be used. Electrification of trucks eliminates the use of oils and greenhouse emissions. However, implementing it requires a new network of chargers. While this network for personal cars is developing, for heavy-duty vehicles, the development is at its root. By studying regulations and long-haul operations in Europe 2023, an estimate of about 40,000 extra overnight changers and 9,000-megawatt charges are found to be required, with a good distribution over serving areas (Shoman, Yeh, Sprei, Plötz, & Speth, 2023).

A similar German study focused on the need for E-trucks, which showed that for 20% electrification, about 1,296 chargers and 457 changing sites must be created in the country (Menter J., 2023). With these requirements, electric battery trucks (BETs) will also have a broader effect on the economy and jobs. As traditional vehicle manufacturing changes, the demand for battery production and electricity supply changes. To allow for a good transition, related skills should be encouraged by the European Union to avoid a skill mismatch in the future (Tamba et al., 2022).

Another approach is the use of hydrogen, which also has similar challenges for broad future use. A study on a hydrogen supply chain in Turkey over the years 2026-2050 addressed four findings. First, in the start, hydrogen fuel will be costly since it is currently not commonly used. However, the price will decrease over time. Secondly, the decentralisation trend works well for a hydrogen supply chain. Thirdly, short travel distances are preferred. Lastly, hydrogen production should be nearby and in low-cost (Erdoğan & Güler, 2023).

1.3.3 Blockchain and Digital Twins

For sustainability in supply chains, gaining visibility and monitoring the activities across the entire supply chain is essential to ensure that suppliers comply with sustainability rules and standards (Grimm, Hofstetter, & Sarkis, 2016). However, globalisation and policy compliance make it arduous for organisations to manage the activities from their first-tier to lower-tier suppliers. Blockchain technology – a promising technology – can improve supply chain transparency, traceability and real-time information sharing across the supply chain (Meier, Gruchmann, & Ivanov, 2023).

Blockchain is a distributed database or digital ledger that records transactional data shared among participants in the blockchain network (Nofer, Gomber, Hinz, & Schiereck, 2017). The transactional data are grouped into blocks, resulting in a blockchain as each block is added to the chain. Decentralisation is one of the most significant properties of blockchain (Saberi et al., 2019). In recent years, supply chains mainly used centralised systems to enable transparency and security of supply chain information and material flow (Abeyratne & Monfared, 2016).

However, decentralisation in blockchain ensures that no single entity or third party can control the network and shared data (Abeyratne & Monfared, 2016). This results in a higher level of transparency and security compared to centralised systems. Saberi et al. (2019) illustrated how blockchain can function within a supply chain to enhance sustainability. According to Saberi et al. (2019), there are four key roles in a blockchain-based supply chain: 1) actors, such as the manufacturers, producers, and customers. 2) Registrars are the ones providing unique identifiers to actors in the supply chain. 3) Standard organisations, like ISO, define policies and requirements for sustainability and blockchain within supply chains. 4) Certifiers allocate certifications to guarantee trust, authenticity, and compliance with all actors within the supply chain.

Additionally, smart contracts are utilised within a blockchain-based supply chain to automatically create, update and implement a contract between actors in real-time, thereby reducing transaction costs and human errors (Abeyratne & Monfared, 2016) (Saberi et al., 2019). (Feng, 2016) adopted Radio Frequency Identification (RFID) and blockchain technology to build an agri-food supply chain traceability system. The findings indicate that implementing blockchain can aid in tracking and tracing product quality across the supply chain. Therefore, blockchain can assess whether companies and products across the supply chain adhere to environmental standards. Various firms have already started adopting blockchain technology to improve their sustainable practices in the supply chain (Ahmed, MacCarthy, & Treiblmaier, 2022).

Furthermore, with emerging technologies such as blockchain, there is a potential to create digital twins for sustainable supply chains. A digital twin is a virtual representation of a system or process, allowing real-time data to flow from the digital to the actual physical environment and vice versa (Grieves & Vickers, 2017) (Fuller, Fan, Day, & Barlow, 2020). As a result, the digital twin technology enables real-time monitoring and the ability to predict the future behaviour of supply chain processes (Cheng et al., 2018) (Ding, Chan, Zhang, Zhou, & Zhang, 2019) (D. Lee & Lee, 2021).

Kamble et al. (2022) recognised that digital twins can support sustainable development. Therefore, the authors presented a sustainable digital twin framework for supply chains consisting of four layers (Figure 3). First, the physical layer encompasses the supply chain's products, systems and people. The physical layer determines the sensors required to capture the data and implement the digital twin. Next, the digital twin of the supply chain is created in the digital supply chain twin layer. Continuous real-time data flow between the digital supply chain twin and the physical layer exists. The incoming data from the physical layer arrives at the digital supply chain twin analysis layer for further research and (prescriptive and predictive) analytics. The digital supply chain application layer identifies how the digital supply chain can

be effectively utilised, and other applications that need to interact with the digital twin are identified. As a result, the digital supply chain twin provides suppliers and decision-makers with insights to improve and achieve sustainable practices.

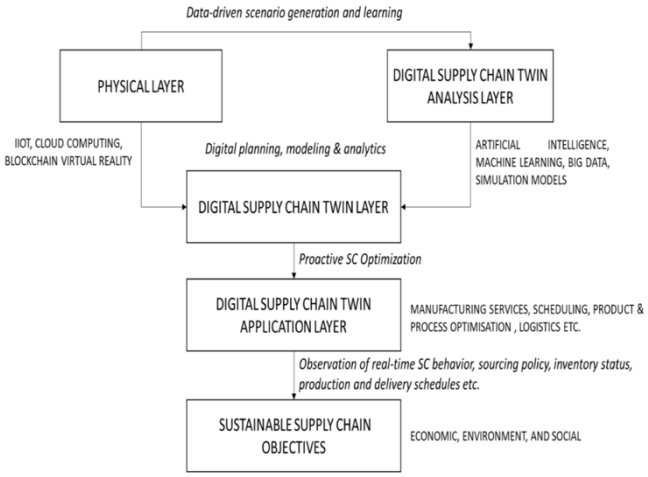

Figure 3 Sustainable Digital Supply Chain Twin Implementation Framework (Kamble, Gunasekaran, Parekh, Mani, Belhadi, & Sharma, 2022).

1.3.4 Circular economy

Drastic changes to the designs of supply chains are necessary to reduce the impact on the environment. Therefore, a circular economy is a way of thinking that ensures supply chain circularity. According to Di Vaio, Hasan, Palladino, and Hassan (2023), circular economy concepts are "development waste management that facilitates new business models, design thinking and a more productive approach for consumption and production. Several frameworks for circular economy exist. The goal of the circular economy is closing the resource loops. The six design options for a circular economy are *repair*, *reuse, refurbish, remanufacture, recycle* and *repurpose* (Lüdeke-Freund, Gold, & Bocken, 2019). All these approaches contribute to rethinking the traditional to a circular supply chain. The design options are shown in Figure 4, which displays the different loops the product will make with the other approaches. The size of the circle also portrays the distance the product must undergo.

The main objective of repair and maintenance is to extend the life span of a product. Certain types of maintenance do this: predictive, preventive or corrective. All these methods contribute to prolonging the product's lifetime by performing a repair to the product. Secondly, there is the approach of reuse and redistribution. This means that the product is sold to a new customer who can use it for the same purpose again. The product should still be working properly. Otherwise, a repair is needed first. This redistribution approach can happen between customers themselves or through the company, which results in a small loop. If a product is not working properly anymore, it is also possible to do refurbishment and remanufacturing.

This means repairing or replacing part of the product with something new to make it work again. In this process, the product's quality is lost, which is different from buying a new one. The product manufacturer mostly does this process. Recycling is possible if a product is too far gone to repair or remanufacture. All the different product materials are separated as much as possible. Then, these materials can be processed to be used again to produce new products.

Therefore, this loop goes from the customer to the parts manufacturer. Often, materials can only be partially separated. Therefore, product parts are also lost. The product should be made of biodegradable materials to avoid this loss of materials. These types of materials can be fully used in biological processes again. Cascading and repurposing are approaches to first exploit all functionalities of the materials of the product parts and then move on to the extraction of biochemical feedstock. Repurposing is a loop that consumers can perform or through the company. Lastly, if there are no other options for the material, the material's energy can be used for production. The product should then go from the consumer to the manufacturer.

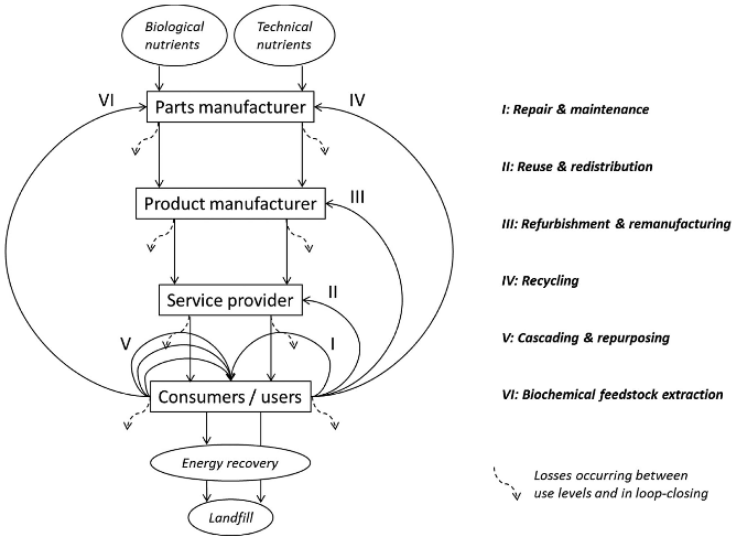

Figure 4 Major reverse cycles for the circular economy

1.4 Description of main findings

The above topics are summarised in the table below with the main findings. It is also stated if the topic relates to recent achievements or if it is an option for future development.

Table 1 The discussed topics with the main findings

Topic	Main finding	Recent or future
LCA	Analyses the entire environmental impact of a product and its processes, from the initial sourcing of raw materials to waste management. Data uncertainty is a limitation.	Recent
Supply chain mapping	Analysing and visualizing information concerning all suppliers (from first to lower tiers) and material flows in the supply chain. Drawbacks: expensive, time-consuming, and heavy on resources. Additionally, there is a lack of specific guidelines for conducting the mapping process	Recent
Perspective of supply chain sustainability	Wieland (2021); the three perspectives are interrelated and are constantly changing.	Future
GSCM	Reliable partnership is important for sharing information about emissions and knowledge of sustainability. The drivers should outweigh the barriers.	Recent and future
Freight consolidation	Collaborate between companies to arrange transport together.	Recent and future
Horizontal collaboration	Verified trough a model that is based on general vehicle and location routing problems. The model positively affects the optimisation of both costs and emissions	Future
Reshoring	Relocating manufacturing decreases emissions but increases costs.	Recent and future
Standardised packaging	Utilising truck space as much as possible but complete redesign of packages should be done.	Future
Electric or hydrogen vehicles	Reduce emissions but the developments are just starting.	Future
Blockchain & Digital Twin	Improves transparency, traceability, and real-time information sharing.	Recent and future
Decentralisation	Ensures that no single entity can control the network and shared data.	Future
Circular economy	Repair, reuse, refurbish, recycle, repurpose are all design methods to increase circularity in supply chains. These design options help close the resource loops.	Future

1.5 Discussion and Conclusion

In the pursuit of sustainable supply chains, it is evident that significant progress has been made, yet a lot of challenges and opportunities still lie ahead. Driven by the growing complexity of supply chains and increasing environmental impact, the sustainable supply chain concept grew. Regulations and laws forced green Supply Chain Management. More recently, measurement tools like Life Cycle Assessment and carbon footprinting have been developed, giving organisations an insight into the impact of their supply chain operations.

Future challenges are vast, ranging from the practicality of transportation to the concept of a circular economy. As road transport is a significant part of a supply chain, thus contributing to many greenhouse emissions, a lot can be gained there. Reducing transportation through freight consolidation, reshoring, and standardising packaging will eliminate fossil fuels by electrifying cars or using hydrogen fuel. Next, blockchain technology shows the potential to enhance supply chain transparency by tracing units and sharing their information in real time. Better monitoring can ensure compliance with sustainability regulations. Another discussed technology is the digital twins, which, through digital representation, provide more accessible insight into optimisation opportunities. Lastly, the concept of a circular economy is discussed, focusing on closing resource loops and minimising waste.

The truly sustainable supply chain has a long way to go. While the combination of the various approaches above is necessary, ideas and theories cannot drive this pursuit alone. Due to barriers, such as financial costs and the complexity of global supply chains, other drivers, such as regulations, will be needed. Furthermore, unexpected events such as COVID-19 or wars may outweigh the set sustainability goals. While it might be an idealistic goal, it seems clear that governments, organisations, and other stakeholders must work together on the future complex problems of the sustainable supply chain.

Chapter 2 - Biodiversity Management
A food supply chain practice view

Carmen Cijffers, Mark de Goeij and Pim Langeveld

Abstract

Biodiversity loss, defined as the loss in the variability of life on Earth, needs to be mitigated. Biodiversity is linked to the sustainability goals: climate change, life below water, and life on land. Causes like population growth, climate change and habitat destruction stimulate this loss, mainly caused by humans. Despite conservation efforts reducing these rates, more must be done. Almost half of the land-based biodiversity footprint comes from housing, agriculture, and the food sector, emphasising the importance of the food industry's role in this challenge. This chapter investigates the food industry's influence on biodiversity. It explores the supply chain and purchasing strategies that could mitigate this loss, supported by understanding biodiversity loss causes, biodiversity management practices and corporate motivations.

2.1 Introduction

Biodiversity loss, which is the loss in variability in life on Earth (Salmi, Quarshie, Scott-Kennel, & Kähkönen, 2023), is a significant topic that needs immediate attention. It is one of the main topics within the sustainability discussion. It can be seen as a combined goal from three of the sustainability goals, namely climate action (goal 13), life below water (goal 14), and life on land (goal 15) (United Nations, 2018). With climate change on the top of the agenda (United Nations, 2018) and with natural disasters like wildfires, floodings, and intense storms globally (Mendonca, 2023; Reuters, 2023; Yousif, 11-08-2023) that threaten life on land and within the sea, it is something organisations must think about. The main drivers for biodiversity loss are population growth, over-consumption, the change and destruction of natural habitats, the direct exploitation of animals and plants, climate change, pollution, and invasive species (Pimm et al., 2014). While Pimm et al. (2014) also mention growth and over-consumption as the main drivers. Salmi et al. (2023) see these as indirect drivers of biodiversity loss.

Nonetheless, both mention the extinction phenomenon (Pim et al., 2014 & Salmi et al., 2023). According to Pimm et al. (2014), extinction rates are exceptionally high, which is probably underestimated because many species have not been discovered yet, and the newly discovered species are already very endangered. The rates are most likely a thousand times higher due to human impact than they should have been due to natural causes (Joppa et al., 2016; Pimm et al., 2014). Luckily, something can be done to prevent biodiversity loss and to have a sustainable food supply chain. Efforts like habitat restoration and regeneration, protection areas, and species translocation have already been made to enhance biodiversity again (Araújo et al., 2019; Salmi et al., 2023). Due to conservation efforts, the extinction rates are currently 20% lower than they would have been if nothing had been done (Pimm et al., 2014). The research “Land-related impact on biodiversity based on demand categories” by

(Wilting, Schipper, Ivanova, Ivanova, & Huijbregts, 2020) shows that household demand, agriculture, and food sector demand contribute 50% of the land-based biodiversity footprint. Because of this, the food sector is the leading sector that must improve to mitigate biodiversity loss.

However, these are very general strategies often executed by nonprofit organisations. Companies, for example, in the food industry, must also do something within the domain of purchasing and supply chain management to ensure that their negative impact is minimised and that their future impact will be positive (Salmi et al., 2023). Biodiversity management must be implemented into the supply chains of companies. However, because of the complexity (Araújo et al., 2019) of the issue and the lack of a clear solution (Salmi et al., 2023), biodiversity loss is considered a grand challenge (Quarshie, Salmi, & Wu, 2021). Furthermore, little attention is given in the research field to biodiversity management within the purchasing or supply chain domain in the food industry. However, there are good reasons to consider this domain. Gavronski et al. (2013) show how differences in environmental policies relate to integration with suppliers and collaboration with external institutions and propose external integration to improve internal environmental management, resulting in a more integrated approach overall.

This chapter researches the impact organisations in the food industry have on biodiversity and what purchasing and supply chain practices they can implement to prevent further biodiversity loss. Thus, the main research question, *"Which strategies in purchasing and supply chain management in the food industry are effective in preventing biodiversity loss?"* is answered. Some sub-questions are constructed to answer the main research question:

- *What is biodiversity and biodiversity loss?*
- *What are the motivations for companies in the food industry to incorporate biodiversity strategies?*
- *What are the mitigation strategies in the food industry to prevent biodiversity loss?*
    - *What can businesses do?*
    - *What can employees do?*
    - *What can suppliers do?*
    - *What can governments do?*

Section 2.2 explains how biodiversity management can be used within the food industry's supply chains by describing how biodiversity loss is caused and by explaining biodiversity management itself. Section 2.3 explains what the motivations are to prevent biodiversity loss for companies in the food sector. Furthermore, Section 2.4 shows what can be done by businesses, employees, suppliers, and governments to mitigate biodiversity. In the end, in Section 2.5, the main findings and conclusions are discussed.

2.2 Biodiversity management within supply chains

2.2.1 Biodiversity loss

Biological diversity, or biodiversity, as it is mainly referred to, is a concept that has always been around us but is something not thought of for centuries. In today's world, it is a topic within sustainability that is at the top of the agenda. According to Boiral et al. (2017) and Quarshie et al. (2021), biodiversity refers to the variability of life on the planet, where the diversity comes from the diversity between species and species' genetic diversity.

Furthermore, the diversity of broader ecosystems formed by this diversity is also essential. Biodiversity is a complex concept and a very crucial one to sustain the natural balance of our planet. It enriches our world with animals and plants, which are vital to food production (Dainese et al., 2019) and sources of medicines (Bouzabata, 2018; Gadioli, Da Cunha, De Carvalho, Costa, & Pineli, 2018). Without biodiversity, humans would not exist.

As stated in the introduction, biodiversity loss is caused by many factors. Some will say climate change is one of the main factors. According to Weiskopf et al. (2020), climate change affects the behaviour of species and how the population is distributed, influencing the population decline. However, others say climate change is not the main factor that causes biodiversity loss. Instead, it is driven by several vital actions (Caro, Rowe, Berger, Wholey, & Dobson, 2022).

Therefore, it detracts focus from habitat destruction and overexploitation. But what are the causes of habitat destruction and overexploitation? According to Isbell et al. (2023), the literature says that land- and sea-use change was the top-ranked direct driver of global biodiversity loss. Habitat loss is a leading cause of biodiversity decline, and globally, it is impossible to obtain a standardised overview (Joppa et al., 2016). A set of underlying causes causes the direct drivers. These causes can be demographic, sociocultural, economic, technological, or related to institutions, governance, conflicts, and epidemics (Díaz et al., 2019). Experts outline that biodiversity loss is caused, in order of decreasing importance, by production and consumption, human population dynamics, governance, trade, and technology (Isbell et al., 2023).

In addition, Salmi et al. (2023) give direct exploitation of animals and plants, pollution, and invasive species as causes. Aronson et al. (2017) even add that urbanisation is one of the greatest threats to global biodiversity. The threats to biodiversity loss are thus driven mainly by human activities, either direct or indirect, and the food industry is a big player within this supply chain. Therefore, these companies can use their supply chain and purchasing management practices to influence the declining biodiversity, both positively and negatively.

In this context, Kashmanian (2019) elaborated on the importance of company supply chains to environmental impacts. Kashmanian states that in every stage of the life cycle of a product, there are possible environmental impacts on biodiversity. Most natural resource impacts and pollution are due to sectors' supply chains, and the food industry supply chain is considerable. However, to be able to make changes to specific products or supply chains, the first step for companies is to have a robust knowledge of biodiversity impacts (Beck-O'Brien & Bringezu, 2021). Companies are not robustly assessing biodiversity and soil and have only begun

acknowledging the risks of increasing biodiversity loss to their supply chains (Di Fonzo & Hime, 2017).

In this chapter, the focus lies on the food industry. In the food industry, one-fourth to one-third of human food is being lost and wasted globally (Chrisendo, Piipponen, Heino, & Kummu, 2023). Moreover, according to O'Brien (2021), food systems depend on biodiversity, but biodiversity loss is causing harm, creating challenges for sustainable food systems. In other words, the food industry relies on biodiversity but dramatically contributes to biodiversity loss.

2.2.2. Biodiversity management

Biodiversity management is a vast and vague topic within the sustainability domain. According to (Salmi et al., 2023), reducing and eliminating adverse biodiversity outcomes and restoring, strengthening, and regenerating biodiversity is the concept of biodiversity management. Boiral et al. (2017) connect it with the corporate side by saying that the processes, products, and projects should be managed to ensure business success while protecting biodiversity. Because of this, the concept of biodiversity management is very complex. Both Aronson et al. (2017) and Salmi et al. (2023) mention that biodiversity management is a challenging topic, and Saberi et al. (2019) state that today's supply chains are becoming more complicated. For example, food supply chains are becoming increasingly complex due to high international dependence from the separation of production and consumption (Erb, Krausmann, Lucht, & Haberl, 2009).

Biodiversity management is often mentioned within sustainable supply chain management. Biodiversity management and sustainable supply chain management are used in a company context to execute all your company activities while caring for the environment (Mastos & Gotzamani, 2022). Sustainable supply chain management is more broadly defined, and biodiversity focuses on preserving Earth's life. Many factors must be considered, like social, cultural, and economic factors that include governance, economics, social networks, multiple stakeholders, individual preferences, and social constraints (Aronson et al., 2017). As a result of globalisation, the variety in company and country cultures, and the different regulatory policies, it is hard and almost impossible to evaluate risk and information within a supply chain (Saberi et al., 2019). In addition, single supply chains are spread out over different continents, making it even harder to trace where products and resources are coming from and their impact (Saberi et al., 2019).

There are many practices which can help tackle the challenges that companies face, the many factors that must be considered, and to make sure biodiversity is preserved. Section 2.4 explains several purchasing, sustainable supply chains, and environmental practices that can be incorporated into the company's strategy.

2.3 Corporate motivations to prevent biodiversity loss

Researchers have attempted to shed light on the motivations of corporations to adjust their supply chain practices to prevent biodiversity loss. One of the measures to indicate corporate intentions concerning sustainability and biodiversity loss is to determine if and how organisations implement Environmental Management Systems (EMS). Martín-de Castro et al. (2016) describe EMS as an environmental-oriented tool, regarded as the management

response to stakeholders' pressures. When considering corporate motivations to prevent biodiversity loss, a distinction can be made between internal and external stimuli. In an exploratory study, Boiral et al. (2017) interviewed 39 experts (i.e., environmental managers, auditors, consultants, etc.). They found three motivations to implement certifiable standards in the area of biodiversity and sustainability, namely: "social acceptability of corporate activities, market pressures and the promotion of a self-regulation rationale" (Boiral et al., 2017). This research highlights how the certification process is merely driven by institutional pressures and the corporate desire to be accepted by society.

Gavronski et al. (2013) describe organisations with an *internal focus* that use certification because they seek improvements in the internal aspects of management. Organisations with an *external focus*, with the main characteristic that the companies focus on social pressure and institutions regulating the environment, and finally, *holistic focus*, which encompasses companies which place higher values on all motivation dimensions, regardless of whether these are internal or external motivation. Heras-Saizarbitoria et al. (2016) surveyed 361 EMS coordinators of Spanish organisations registered with EMAS and determined motivational variables within the three clusters defined in the taxonomy of (Gavronski et al., 2013). Heras et al. (2016) emphasise the importance of *internal motivation* as a driver for achieving higher outcomes from adopting EMSs. These companies intend to improve environmental practices and performance, not companies that aim to improve their image (Heras-Saizarbitoria et al., 2016).

When assessing motivation, risks to corporate business performance can also be used as a starting point to identify why businesses may want to prevent biodiversity loss. Kashmanian (2019) mentions several risks in different managerial categories:

- operational: increase in cost and scarcity of raw materials
- market: customers choosing alternatives (e.g., to sustainable sourced or certified goods) and governments changing policies
- regulatory: new regulations formed by governments
- reputational: reputation harm from media, activist campaigns, shareholder decisions, and shifting customer preferences
- access to capital: limited access to capital due to changing capital and lending policies

This section provides insight into corporate motivations to prevent biodiversity loss within the supply chain practice view. A combination of internal and external factors influences these motivations. In this context, internal motivations are primarily driven by a genuine commitment to sustainability and biodiversity protection, whereas societal pressures and market demands mainly influence external motivations. It is vital to note that internal factors have been shown to lead to more significant outcomes when implementing EMSs. Understanding these motivations is essential to understanding how biodiversity management functions and can be influenced by the supply chain practice view.

2.4 Mitigation strategies

To reduce the risks of biodiversity loss, we propose mitigation strategies. According to Wilting and Oorschot (2017), three well-known types of mitigation strategies are (i) reducing direct pressures, (ii) reducing the use of resources, and (iii) changing procurement patterns and locations. These strategies are still broad and state the complexity of reducing biodiversity loss. Therefore, this section elaborates on effectively implementing these main mitigation strategies. The focus will be on the food industry to make this easier to grasp. Generally, sectors with a high share of direct impacts on biodiversity should have mitigation strategies focusing on their activities and pressures (Wilting & van Oorschot, 2017). The following sub-sections dive deeper into different stakeholders within the food industry and their mitigation strategies.

2.4.1 Businesses

"Make biodiversity protection every business's business." (Panwar, 2023, p. 3611). This is one of the five strategies of Panwar to bring change in business practices. To achieve sustainability within a business in the food industry, there should be a desire to be more environmentally responsive, which is often derived from external pressures (F. E. Bowen, Cousins, Lamming, & Farukt, 2001). For example, a national supermarket chain can source a significant part from local suppliers to pass on their desire to become sustainable. Therefore, a second strategy of Panwar (2023) is to give biodiversity a central stage in the corporate sustainability discourse. This makes sure that the company will always involve biodiversity initiatives. This is not only morally essential but also strategic. Within the food industry, this could mean that restaurants, for example, focus more on menu innovation since that is the core of the business. Businesses in the food industry that adopt biodiversity standards encourage better stakeholder relationships with NGOs and other organisations that value nature conservation (Boiral et al., 2017). Biodiversity standards also contribute to structuring new biodiversity practices and distributing new knowledge among managers and employees. Subsection 2.4.2 elaborates more on the employee awareness side.

A business should understand its biodiversity performance. Therefore, they must use indicators to help them know where to start reducing and preventing biodiversity loss. An example of an indicator is biodiversity footprint, which can act as a 'headline indicator' to communicate the pressure on biodiversity. The biodiversity footprint indicates how much biodiversity is lost or at risk for the production and consumption of specific products across the lifecycle of the products (Beck-O'Brien & Bringezu, 2021). Using this, high-impact products in the food industry can be identified, and biodiversity loss minimised.

Within the food industry, every business has suppliers and customers. Thus, a company can also be a supplier or a customer of another business. Beck-O'Brien and Bringezu Field (2021) state that companies can lead towards sustainable food systems. They can demand higher levels of biodiversity inclusion from suppliers and help customers make more sustainable choices. Examples of businesses in the food industry are farmers that directly impact biodiversity through land use, food processors with resource-intensive production methods and supply chain practices, and retailers and supermarkets that can promote sustainability. They may take on more responsibility as the last link of a globalised supply chain (Beck-O'Brien & Bringezu, 2021). This is because retailers directly interact with the customer and can,

therefore, raise awareness and promote sustainable products. This is further explained in Subsection 2.4.3.

2.4.2 Employee awareness

In 2001, Bowen et al. indicated that "technical skills and competences of Purchasing personnel may be a critical resource in building green supply capabilities", where 'green supply capabilities' are supply management activities that attempt to improve the environmental performance of purchased inputs, or of the suppliers that provide them (F. E. Bowen et al., 2001, p. 177). However, it is also emphasised that green supply capabilities must be supported by a proactive corporate environmental stance and a highly strategic purchasing and supply process (F. E. Bowen et al., 2001). More recent literature places more emphasis on biodiversity practices specifically and the motivations and activities of employees. One paper highlights that the proactive stance of employees is one of the main drivers for improved biodiversity practices in industries that heavily rely on natural resources, such as the food industry (Boiral, Heras-Saizarbitoria, & Brotherton, 2019). Boiral et al. (2015) have shown before that employee pro-environmental actions can lead to symbolic or significant integration of environmental practices in daily activities.

However, it was also noted that employee behaviours for biodiversity conservation are limited due to the complexity of biodiversity issues and organisational deficiencies, i.e., lack of clarity in corporate commitment, externalisation of initiatives, and lack of employee training and skills (Boiral et al., 2019). This is supported by the argument that certification helps structure new biodiversity practices and distribute further information among managers and employees who lack the expertise to implement new policies (Boiral et al., 2017). Considering long-distance food supply chains, O'Brien and Bringezu (2021) concluded that the food industry is positioned to demand higher levels of biodiversity inclusion from suppliers and help customers make more sustainable choices. To increase employees' impact, they need to be accompanied by a desire in the companies to be more receptive to environmental practices (F. E. Bowen et al., 2001).

To empower this, it is recommended that companies use certification to help structure biodiversity practises, emphasise the corporate desire, and formalise knowledge distribution within the company. Additionally, businesses can be motivated to support their employees with biodiversity practises if the supply chain demands this.

2.4.3 Suppliers

One of the five strategies of Panwar (2023) to bring change in business practices is to hold businesses accountable for biodiversity impacts across their entire supply chain. A company should not only investigate its performance on biodiversity loss but also the performance of its suppliers. More than 45% of the impacts in the food industry were caused upstream of the direct suppliers (Wilting & van Oorschot, 2017). Companies should create insights into the practices of their direct suppliers to influence these suppliers. A typical starting point for businesses to engage with their supply chain is the development of supplier codes of conduct (Kashmanian, 2019). The company states its requirements of suppliers by establishing standards that cover the behaviour and practices of suppliers. Based on these, suppliers understand the business's expectations before becoming partners. An example from the research article of Kashmanian is the supplier codes of conduct of Unilever:

“Good biodiversity and ecosystem services management is important for Unilever because biodiversity enhances the resilience of agri-ecosystems, making them more resilient to stress and shocks…. Programs that link farming activities with biodiversity conservation contribute to reducing or eliminating threats to biodiversity. This will result in better species conservation and support a wide range of ecological processes that provide ecosystem services.” (Unilever & Smith, 2017, p. 92).

In some cases, the supplier codes of conduct standards might align with the standards of the third-party certifications. Third-party certifications can contribute to benchmarking biodiversity-friendly business practices (Panwar, 2023). These, therefore, often focus on specific areas. Using these certifications, businesses can assure their customers that their products do not cause harm to biodiversity, and they can be rewarded by improving their position in the market. They can include several standards, guidelines, and criteria the supplier should meet to earn the certificate. For example, on the extent of promoting sustainable land use practices on corn fields to minimise habitat destruction. Suppliers are expected to comply with these standards, or in some cases, they can already show certificates.

A collaborative relationship with suppliers may be a pivotal resource to facilitate green supply (F. E. Bowen et al., 2001). Using this relationship, they can understand the environmental impacts of each other. This improves the mutual commitment to shared goals and values. For example, a local restaurant can start a relationship with a sustainable farm in the neighbourhood. To have a strong relationship, clear communication is essential to clarify expectations.

2.4.4 Regulations and policies

All the strategies and practices are attractive, but companies are sometimes not eager to implement them if there is no external pressure, as explained in Section 2.3. Therefore, governments must integrate it into their national policy, put it into official documents and make regulations (Salmi et al., 2023). Several examples of policies and regulations in the biodiversity domain ensure biodiversity preservation.

According to (Zakharchenko et al., 2018), seven ecological programs have been developed and accepted since 1973 to ensure structural biodiversity improvements. Examples of these regulations are the need for bird and animal protection policies and policies for agriculture and urbanisation of natural habitats (Zakharchenko et al., 2018). These problems can and must be solved jointly by having an international approach. The most relevant aspects of ecological policy to consider are the following:

- Develop a long-term and preventive concept and joint solution to global ecological problems by having active participation of every participant.
- Establish an optimal level of taking necessary measures. The levels to choose from are local, regional, national, and international.
- Shift the expenses to prevent and eliminate ecological damage. Also include the “pollutant pays” concept.

When looking at the food industry, a certain type of policy is often seen in the literature (Santamaría & Méndez, 2012). The policy is the conservation and protection of rare species

and habitats. For example, in fishery, preserving the fish population and the different species must be considered. Special care must be taken not to limit the gene pool within the fish population to ensure the genetic variation stays abundant (Santamaría & Méndez, 2012). Furthermore, most conservation policies are too late to address that species must be protected and their habitats should be conserved. Mostly, when these species are already endangered, policies are made (Santamaría & Méndez, 2012). Thus, knowledge needs to be spread among food companies and policymakers to ensure policies are made before it is too late.

In the Convention on Biological Diversity signed in 1992, considered the central policy for biodiversity, Aichi Biodiversity Targets were made that had to be reached by 2020 (Santamaría & Méndez, 2012). Eight out of twenty targets can be directly linked to the food industry. The targets highlight that awareness should be created, harmful incentives should be eliminated as well as the decrease in pollution, sustainable production should be reached, natural habitat loss due to agriculture should be brought to zero, overfishing is avoided, and the most important one: the genetic diversity of cultivated plant and farmed animals is maintained. The European Union also has several policies related to the CBD mentioned above (Santamaría & Méndez, 2012). Although policies are made the targets are still not reached and thus policy-relevant knowledge must be generated (Santamaría & Méndez, 2012). Especially the lack of collaboration between science, business, and policy is still one of the biggest challenges of biodiversity conservation.

2.5 Discussion of the findings and conclusion

This chapter highlighted how biodiversity is important, and that the food sector is a prominent contributor to biodiversity loss and must improve biodiversity loss mitigation. The following conclusions can answer the research question “Which strategies in purchasing and supply chain management in the food industry are effective to prevent biodiversity loss?”.

We have shown that biodiversity loss is influenced mainly by human activities, especially within the food industry supply chain, emphasising the need for companies to evaluate and mitigate their biodiversity impacts to address the food sector's biodiversity challenges.

In the context of sustainable supply chain management, biodiversity management is further complicated by globalization, diverse cultural factors, and intricate supply chain networks that span multiple continents. We underscore the importance of incorporating various sustainable supply chain and environmental practices, as discussed in Section 2.4, to address these challenges and effectively preserve biodiversity in corporate strategies.

We can see in Table 1 below the mitigation strategies that stakeholders can use to prevent biodiversity loss. An example from practice relates to the food industry in the right column.

Table 2: Mitigation strategies.

Stakeholder	Mitigation strategy	Example in practice
Businesses	Make biodiversity every business's business.	A national supermarket chain can source a significant part from local suppliers.
	Give biodiversity a central stage in the corporate sustainability discourse.	Menu innovation in restaurants.
	Use indicators on biodiversity performance	Biodiversity footprint as headline indicator.
Employees	Educate and inform employees on how to implement biodiversity practises	NGOs willing to cooperate with the private sector to provide training to employees to bridge the gap between the complexity of business and complexity of biodiversity (Boiral et al., 2019, pp. 694-695).
	Use certification and supply chain demands to help structure biodiversity practises	A manager is externally motivated to support employees with their biodiversity practises
Suppliers	Set up supplier codes of conduct.	Unilever stated in their supplier codes of conduct that they want to develop programs that link farming activities with biodiversity.
	Develop third-party certifications with standards.	The extent of promoting sustainable land use practices on corn fields to minimize habitat destruction.
	Collaborative relationship.	Between a local restaurant and a sustainable farm in the neighbourhood.
Policy makers	Develop a long-term and preventive concept by having an active participation of every participant to come to a joint solution.	Between several actors in the food industry (e.g., farmers, food manufacturers). Reduction of pesticide usage and deforestation for agriculture.
	Include the pollutant pays concept.	The companies that pollute should pay the costs for cleanup and building up again. If rivers are polluted due to bad drainage.
	Conservation and protection of rare species and habitats.	No deforestation for agriculture but develop innovations to increase production.
	Create awareness and collaboration.	Train local farmers and give subsidies for innovations. Make it so that the collaboration within the supply chain would benefit from biodiversity mitigation.

Chapter 3 - Purchasing Competencies for Sustainable Sourcing

Stijn Korfage, Jimmy van Santen and Eva Stoica

Summary

With the transformation of purchasing and supply management (PSM) tasks into strategic functions, the role of the purchaser evolved. The PSM professionals become boundary spanners and need new knowledge, skills, and attitudes to navigate a dynamic digitalisation, innovation, and sustainability environment. Hence, this chapter investigates these capabilities and groups them into knowledge, attitudes and skills. Furthermore, it depicts the intersection of moving towards sustainable practices (such as offshoring and onshoring), circular economy and new technological advancements.

3.1 Introduction to purchasing competencies

Purchasing and supply management (PSM) has transformed from traditional, transactional tasks, such as securing the price-quality balance, towards more strategic tasks, like innovation sourcing and co-developing sustainable products and services (Schoenherr et al., 2012). Traditionally, the role of a purchaser was focused on finding and sourcing products at low costs from suppliers (Bals, Schulze, Kelly, & Stek, 2019a). However, as new trends emerge, the dynamics are rapidly shaped by new technological developments, innovation, and sustainability as driving forces behind corporate decision-making. This shift promotes a more connected landscape in which organisations interact globally.

The imperative to reduce environmental impact, promote ethical practices, and ensure the long-term viability of supply chains has led to a significant shift towards sustainable sourcing in procurement (Schneider & Wallenburg, 2012). As organisations increasingly recognise the need to embrace sustainability and address issues like climate change, environmental management or regulatory compliance, a profound transformation is underway within the procurement realm. Furthermore, the rapid changes in the dynamic business landscape shaped by digitalisation, innovation, and sustainability bring to light new questions regarding how a company would succeed over a more extended period.

3.2 The need for new competencies for sustainable sourcing

The impact of such transformations leads professionals in PSM to become boundary spanners. A new array of competencies is needed for purchasing processes to face the increasing demands for sustainability and digitalisation and handle geopolitical consequences. Under the umbrella term “competencies”, soft skills represent necessary conditions for carrying out hard or professional skills, knowledge and attitudes (Kiers, Seinhorst, Zwanenburg, & Stek, 2022; Stek, 2021a, 2021b; Stek & Schiele, 2021).

This chapter will explore the future competence requirements for PSM professionals in the face of increasing demand for innovative and sustainable product and service solutions. The main research question (RQ) has been defined as:

Main RQ - What competencies must PSM professionals possess to effectively adapt to the dynamic environment of digitalisation, innovation, and sustainability?

Three sub-research questions have been envisioned to help tackle the complexity of the main RQ. They will focus on sustainable aspects, such as onshoring, circular purchasing or technology advancements that aid the people, planet, and profit (Elkington, 1999).

RQ1 - Which competencies are needed for sustainable PSM in the case of both onshoring and offshoring?

RQ2 - How does the array of competencies of a purchaser change in light of the emergence of circular, sustainable purchasing?

RQ3 - What is the impact of technological advancements focused on supporting sustainability on the skill set of purchasing and supply chain managers?

3.3 Literature Review on Sustainable, Innovative and Digital Competencies

3.3.1 Methodology overview for research on sustainable and innovative PSM

For each of the three RQs, a systematic literature review was conducted. Two main domains were used: Scopus and Google Scholar. Relevant keywords were used to guide the search. For the first RQ, search terms such as "sustainable onshoring and offshoring", "purchasing manager skills", and "purchasing competencies" were researched. For the second RQ, the guiding elements were "industrial symbiosis", "supply chain*", "collaboration* or network", as well as "resilience", "circular*", and "purchas*". A combination of these terms was used, and ten papers were reviewed. Lastly, for the third RQ, relevant keywords such as "technological advancements", "sustainable supply chain", "digitalisation", "managers" and "skill set" were used.

With the keywords set, a selection of pertinent literature was performed. As the topics of interest are new, all the results were refined based on relevance, number of citations, and year. For each research question, recent literature was synthesised.

To understand what competencies are, the findings will be categorised into knowledge, skills, and attitudes, as in literature, two relevant papers touch upon these points. The first is the attitudes, skills and knowledge, or the KAS model proposed by Bakarman (2005). In contrast, the second is the typology created by Winterton, Delamare- Le Deist, and Stringfellow (2005).

The ASK model (Bakarman, 2005) aims to prepare students for professional practice and provide the required means to practice successfully. "ASK, as an educational model, aims to identify them [aspects that can be obtained and acquired by an individual] by decomposing design education discipline into manageable elements that reflect the main ingredients" (Bakarman, 2005, p. 1). The main elements, according to the model, are "professional attitude, design skills, and professional design knowledge" (Bakarman, 2005). Attitude describes the behaviour aspects of students, skills represent their capacity to identify a problem and provide a solution, and knowledge discusses the professional knowledge that allows students to think and act in a formal and polished manner. As the management of the buyer-supplier interface is critical, and given that "a typical industrial firm [in Europe] spends about 60% of their turnover on purchased components" (Zunk & Koch, 2022), the education of purchasers is necessary. Thus, combining the ASK model, oriented towards the education domain, can broaden the perspective from just listing capabilities to understanding how these can be acquired for upcoming developments.

Winterton et al. (2005) created a typology of knowledge, skills, and competencies to further support the ASK model's use. Knowledge includes "underpinning theory and concepts, as well as tacit

knowledge gained as a result of performing certain tasks" (Winterton et al., 2005, p. 9). Skills reflect a certain level of performance. Lastly, competence is described as a "fuzzy concept", which can be seen as an overarching term encompassing knowledge, skills, and abilities. In this case, the abilities are like attitudes. Knowledge is part of developing skills, "[…] prerequisite to developing competencies along with attitudinal or social factors" (Winterton et al., 2005, p. 17). A unified typology is being proposed, which contains knowledge (cognitive competence), skills (functional competence) and attitudes (social and meta-competence).

Hence, based on the ASK model and the typology, the literature findings will be structured along the three domains: knowledge, skills, and attitudes.

3.3.2 Sustainable onshoring and offshoring: Reshaping the competencies of tomorrow's purchasing and supply managers

As organisations reconsider their sourcing strategies, PSM professionals' roles and competencies are being reshaped. The resurgence of onshoring is a strategic shift caused by global disruptions and the need for supply chain resilience. Understanding the extent of this transformation is crucial for adapting to the evolving landscape. This complication relates to the first sub-RQ, ***"Which competencies are needed for sustainable PSM in case of both onshoring and offshoring?"***.

Neither purely local nor entirely global production systems have the 'perfect' solution for a sustainable world. Onshoring and offshoring have pros and cons (Clarke-Sather & Cobb, 2019). A proof-of-concept legging design shows when a company needs to decide to either onshore or offshore their supply and production. However, neither local nor global production has been investigated excels in all sustainability areas (Clarke-Sather & Cobb, 2019). Consequently, there is a challenge for purchasers and supply managers, who must have the skills to make informed and sustainable decisions, whether considering onshoring or offshoring.

It is essential to differentiate 'offshoring' and 'onshoring' to understand these decisions. Onshoring is the opposite of offshoring or moving production to countries with lower wages and fewer environmental and safety regulations. The offshoring process transfers a part or all the value-added activities a company executes from the home country to another. Important to mention is that the firm maintains ownership over overseas activities (Baldassarre & Campo, 2014). Thus, with onshoring, manufacturers are returning part or all of their foreign production to domestic facilities (Kazmer, 2014).

The decision-making process for onshoring and offshoring can benefit from the "life cycle assessment approach", which holistically evaluates a product's or strategy's impact over its lifespan. Global sustainability impact is a compilation of social, environmental, and economic impacts. "Sustainable development is not a process that happens 'over there'. All parts of the globe and global economy are interlinked" (Clarke-Sather & Cobb, 2019, p. 1214). It reinforces that only the initiatives and actions that benefit the global citizen matter.

But how to measure the competencies essential to face these modern challenges? To categorise the competencies, attitudes, skills, and knowledge will be used.

Regarding knowledge, the future PSM professional should understand the local and international markets. In other words, they should have local and international market intelligence. In addition, the future PSM professional should have enough knowledge about sustainability and compliance. Decisions regarding on and offshoring involve financial, social, and environmental factors. To illustrate this, the European Union is introducing an emissions trade system for industries (European Parliament, 2018).

Introducing skills beyond being reactive, the professional should become proactive, ensuring long-term decision-making. It connects to critical thinking, system thinking, mitigating risks, and adaptability to change.

The PSM professional should also have the right attitude: commitment to change and criticality. If supply chains are getting more flexible, the purchaser must have a particular commitment to change (Schulze, Bals, & Johnsen, 2019).

3.3.3 Role of a PSM professional in circular purchasing

Sustainability is transforming today's economy from a linear to a circular model. Overcoming the hurdles of traditional "take-make-dispose" and the issues of resource scarcity created a paradigm shift in which an efficient use of available resources is essential. Based on this shift, the second sub-RQ, ***"How does the array of competencies of a PSM professional change in light of the emergence of circular, sustainable purchasing?"*** aims to discover how the change affects purchase professionals.

In a circular economy (CE), "the value of products and materials is maintained for as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value" (Neessen, Caniëls, Vos, & de Jong, 2021, p. 1). This concept requires a different organisational design in which principles such as reusing, refurbishing, or rethinking are included in the purchasing function. Moreover, as regulations and rewards for circular activities are still being developed, purchasers are pivotal as CE depends on their internal activities and practices.

New industry clusters, such as industrial symbiosis networks, have emerged to achieve a circular economy. These refer to the creation of collaboration and synergies between traditionally separated industries, in which materials, energy, water or by-products are transferred from one to another based on geographic proximity (Fussone, Dominguez, Cannella, & Framinan, 2022; Herczeg, Akkerman, & Hauschild, 2018). The purchaser and supplier relationships expand towards previously unrelated companies (Herczeg et al., 2018).

To provide an answer to the second sub-research question and understand the needed competencies of a PSM professional, first, the focus will be on the role of purchasers in the implementation of circular purchasing. Afterwards, the intricacies a purchaser must navigate in an industrial symbiosis network will be investigated.

Circular procurement "entails considering durability, resource efficiency, reuse, recyclability, refurbishment/retrofitting and buying recycled during the procurement process" (Al-Sinan & Bubshait, 2022, p. 7). A traditional purchaser's knowledge, skills, and attitudes should considerably transform when moving towards CE.

In terms of knowledge, the PSM professionals must understand what CE is to participate in activities such as Green Deal Circular Purchasing to develop a broader understanding of circularity (Neessen, Caniëls, et al., 2021) or comprehend the life cycle assessments that can be related to costs of products. Al-Sinan and Bubshait (2022) describe a wide array of knowledge elements that one must possess to work with circular purchasing. The professional must have environmental awareness and education, know how to design for longevity, reliability or durability and recognise which laws and regulations are in place. Moreover, being aware of the technical standards of products and having material literacy (Deloitte, 2021) will ensure that purchasers can perform their activities with circularity in mind. For procurement, the circularity of materials in design also means that the PSM professional should be involved in the design process from the beginning.

Al-Sinan and Bubshait (2022) also illustrate possible CE strategies for procurement procedures, as seen in Table 3.3. Thus, understanding the CE principles and potential strategy for narrowing, slowing, or closing loops is essential (Al-Sinan & Bubshait, 2022; Mwesiumo, Kvadsheim, & Nujen, 2020).

ACQUISITION TYPE	STRATEGY
Raw material	Reduce
Product with a single material	Recycle/refurbish/reuse
Product with multiple materials	Refurbish/reuse/disassemble
Mechanical/electrical product	Repair, prolonged lifecycle, remanufacture, lease
Workforce service	-
Workforce/equipment	Shared services
Human resource/equipment/product	Servitised business models and shared services
Construction project	Lifecycle assessments

Table 3.3: CE Procurement Strategies

When discussing skills, Neessen, Caniëls, et al. (2021) and Neessen, de Jong, Caniëls, and Vos (2021) explain that the most important one is being intrapreneurial. Under this umbrella term resides the essence of a purchaser. Being intrapreneurial means being innovative and proactive, exploring and exploiting the market, taking risks and networking. This is part of the framework of intrapreneurship proposed by Neessen, Caniëls, et al. (2021). The purchaser must collaborate with new suppliers, as the traditionally unrelated industries aim to create synergies. The organisation will develop new products, processes and services in a CE manner that can help enhance competitiveness and performance.

Another skill that must be acquired is the formation of roadmaps with budget holders in which sustainability goals will be included. "The purchasers in organizations that are successful in implementing circular purchasing are more active and feel a joint responsibility with budget holders to reach company goals concerning circularity" (Neessen, Caniëls, et al., 2021, p. 5). In terms of balance, one must be created between costs and sustainability, as well as for long-term visions and short-term plans (Al-Sinan & Bubshait, 2022). Furthermore, the purchasers should discern how to put the right people together to reach sustainable practices and ensure that sustainability success stories will be shared within the company (Neessen, Caniëls, et al., 2021).

For circular procurement, the purchaser skills are related to creating synergistic partnerships and the ability to do traceback management to understand potential issues within the supply chain. The partnerships connect to the capacity of a PSM professional to explore the potential for exploiting residual values of resources whilst looking for new opportunities or desiring to innovate with current suppliers (Al-Sinan & Bubshait, 2022; Mwesiumo et al., 2020).

A few aspects discussed by Deloitte (2021), such as compliance or resilience, are intertwined with the knowledge and skills of purchasers. They should master how key performance indicators (KPIs) and tools can be leveraged to measure risks, product, and organisation environment footprints. For example, when selecting a supplier, the purchaser must understand "environmental-related certifications, standards, clean technologies or eco-transportation" (Münch, Benz, & Hartmann, 2022, p. 14).

Having the knowledge and skills for CE procurement is not sufficient, as the attitude of an individual plays a more critical role. The purchasing professional must be motivated and willing to embrace sustainability and be a leader who takes initiative and encourages being circular-minded (Neessen, Caniëls, et al., 2021). Promoting new business models based on innovative, resource-efficient, and circular supply chain solutions becomes more critical. Currently, there are no rewards for circular purchasing. The individual should show organisational citizenship behaviour for the environment (Neessen, de Jong, et al., 2021), meaning that voluntary environment actions going beyond job

requirements will be beneficial. One important note is that a buyer should be willing to pay a premium, which will yield a return in the long run for the benefit of society and global sustainability (Al-Sinan & Bubshait, 2022).

3.3.4 Competencies needed in industrial symbiosis networks

One of the needed skills of the purchaser is analysing possibilities for industrial symbiosis (Mwesiumo et al., 2020). As symbiotic buyers and suppliers (Turken & Geda, 2020) emerge in such a network, the PSM professional becomes a boundary spanner working with previous unrelated industries. The symbiotic supplier provides waste or by-products for the buyer but does not produce them directly for the purchaser. This means that an essential skill of a purchaser will be to deal with uncertainty, as he might not have access to detailed information regarding the quantity or quality of by-products that a supplier produces. Grasping the uncertainty leads to new skills, such as risk monitoring and creating strategies in case of disruptions.

The ability to manage risks and navigate a more complex environment, in which relationships with new companies or industries must be created, is supported by Fussone et al. (2022) and Herczeg et al. (2018).“Losing a buy-product supplier, for example, due to relocation or change in by-product characteristics, can endanger the integrity of the network” (Herczeg et al., 2018, p. 1063). Determining how to draft supply-demand agreements will help the supply chain's resilience. Furthermore, designing strategies and contracts with the suppliers to increase diversity of exchange or redundancy is believed to help manage a network's risk and resilience (S. S. Chopra & Khanna, 2014).

The prevalent knowledge of industrial symbiosis networks entails understanding CE, agent-based modelling (as it can help with the study of cooperation dynamics), as well as different types of costs: transaction, transportation, or treatment (Fussone et al., 2022; Herczeg et al., 2018; Turken & Geda, 2020). Having a better understanding of various industries or region-specific knowledge are also elements that can make the purchaser a boundary spanner (Herczeg et al., 2018). Using tools like information-sharing platforms (Deloitte, 2021; Turken & Geda, 2020) allows a more straightforward market analysis.

As previously mentioned, the attitude of a purchaser in an industrial symbiosis network differs from the traditional one. The individuals must work towards the same goals, gaining profit and improving environmental aspects. With the help of benefit-sharing schemas, a coopetition (cooperation & competition) model can be created. Fostering eco-innovation and long-term culture changes are crucial drivers for one’s attitude.

3.3.5 Technological advancements and their impact on PSM competencies

Lastly, rapid technological advancements are pivotal in shaping the skill sets of purchasing and supply chain managers. Automation, data analytics, and digital tools are revolutionising procurement processes. Understanding the impact of these technological changes on competencies is vital for staying competitive in the modern marketplace. These factors lead to the formulation of the third research question, “***What is the impact of technological advancements focused on supporting sustainability on the skill set of purchasing and supply chain managers?”***.

Because technology has revolutionised almost every aspect of our lives, the future promises an ever-increasing reliance on it. Industries are changing, becoming more efficient, and open to new opportunities thanks to artificial intelligence (AI), automation, and data analytics developments. The environment is more intelligent and responsive because of connectivity via the Internet of Things (IoT), cyber-physical systems and the transitions towards Industry 4.0 and 5.0. Communication, education,

and individualised services will all undergo radical changes. Solutions for sustainability that are tech-driven will be required due to environmental challenges. As a result of the pandemic's acceleration of digitisation, technology has become crucial to areas such as remote employment, e-commerce, and virtual experiences. The reliance on technology increases as it becomes the lynchpin of advancement and convenience as innovation continues.

As explained, technology will have more influence on the world, and people will be more dependent on technology than they are now. This also brings uncertainties in various activities. In the literature, an example is given, discussing the learning of PSM: In light of rising levels of automation, are students better prepared for a future career in PSM by learning the fundamentals of processing purchase orders from a textbook alone, or should their education also include project-based instruction on how to create processes and have them carried out digitally while having a thorough understanding of the role of information technology (Bals et al., 2019a)?

Digital technologies and advancements will have more and more influence and impact on the world and the purchasing and supply chain environment. For example, recent research in the purchasing discipline supports the notion that digital technologies, such as AI, will enable more evidence-based decisions in supplier selection or assist sustainable procurement decisions (Allal-Chérif, Simón-Moya, & Ballester, 2021). By quickly and accurately analysing massive data sets, AI supports evidence-based supplier selection and sustainable procurement. Real-time insights are provided by AI-driven analytics that evaluate supplier performance, risk factors, and environmental effects. Organisations may make wise decisions using machine learning algorithms to discover trends, uncover hidden patterns, and foresee possible problems. Natural language processing makes sentiment analysis of supplier interactions possible, enabling evaluation of reputation and dedication to sustainability objectives.

AI and automation in digital technologies (logistics infrastructure, self-driving cars and trucks) are significant forces in developing evidence-based decision-making in sustainable sourcing decisions (Beske-Janssen, Johnsen, Constant, & Wieland, 2023). AI, for instance, can quantify sustainability measures like social effects and carbon emissions, providing a solid foundation for ethical sourcing decisions. Automation also ensures that sustainability practices are used consistently and are being tracked, which supports continuous improvement in supply chain sustainability. Automation also enables firms to invest more resources in sustainable practices by streamlining procurement procedures and lowering operating costs.

The skill sets required of purchasing and supply chain managers are drastically changing because of rapid technological improvements. Understanding the effects of these technologies is crucial for being competitive in the market today. These professions, historically relying on manual processes, now call for knowledge in automation, data analytics, blockchain, and artificial intelligence. Adaptability and a commitment to lifelong learning are essential for today's field professionals. Success in the dynamic, sustainability-focused global corporate climate requires embracing these changes and obtaining these critical skills. Also, purchasing must adjust to higher-value jobs, such as those that are more strategic, complicated, and diversified, because of the digital transition. These higher-value activities are related to cognition-focused skills and competencies (Schulze et al., 2019).

The literature has already documented that functionally oriented competencies, primarily needed in supplier relationship management, include skills linked to digital tools in procurement (Schulze & Bals, 2020). The competencies needed for staying competitive in the modern marketplace focused on sustainability when looking at the impact of technological changes can be divided into attitudes, skills, and knowledge.

Starting with knowledge, purchasing and supply chain professionals need to understand different fields and aspects of the upcoming technology. For example, understanding how automation can aid with the sustainability of the supply chain is essential. With knowledge about automation, managers can improve sustainability by minimising waste and maximising resource use. Thus, sustainability goals can be supported by eco-friendly automation solutions.

Comprehending and working with big data analytics became relevant. The ability to make data-driven decisions, optimise resources, track performance, minimise environmental impact, manage risks, engage stakeholders, spur innovation, ensure compliance, and gain a competitive edge is a skill that knowledge about big data analytics gives managers. These factors are crucial for achieving sustainability goals in the current business environment.

Managers who want to promote sustainability inside their firms must understand innovative sourcing. This enables businesses to make well-informed decisions that support sustainability objectives, lower costs, manage risks, adhere to legal requirements, and satisfy the demands of stakeholders who value the environment and society. Ultimately, this results in long-term success and ethical business practices (Bals et al., 2019a).

Going beyond knowledge, skills that managers need because of rapid technological advancements are investigated. Critical thinking (Bals et al., 2019a) is an essential attribute of a PSM professional. Purchasing and supply chain managers who want to promote sustainability must have critical thinking abilities. They make it possible to solve problems effectively, make moral decisions, innovate, and deal with sustainability difficulties in a technological environment that is constantly evolving.

Professionals looking to use modern technology to improve sustainability must also possess strong analytical skills (Beske-Janssen et al., 2023). They make it possible to decide based on data, spot opportunities, optimise resources, evaluate risks, and effectively incorporate technology into sustainability initiatives. These competencies are crucial for firms to succeed in a market that increasingly places a premium on sustainability.

Due to rapid technological advancements, some specific attitudes are essential when being a manager. Curiosity and mobility are the most important (Bals et al., 2019a). Innovation, learning, problem-solving, and adaptability are all enabled by curiosity, all necessary for utilising cutting-edge technologies to improve sustainability. It gives managers the freedom to take advantage of new opportunities, work successfully with stakeholders, foster a culture of continuous improvement, and responsibly integrate new technologies.

A mobile mindset must be adopted to successfully traverse the sustainability landscape, which is constantly changing due to emerging technology. It enables them to manage risks, develop innovation, encourage change, and steer their firms toward more environmentally friendly practices that are good for business.

3.4. Answers to the newly required competencies

3.4.1 Competencies for onshoring and offshoring

The competencies needed for a sustainable PSM professional, in the case of both onshoring and offshoring, are summarised in Table 3.4.

Table 3.4: ASK for offshoring and onshoring

	KNOWLEDGE	SKILLS	ATTITUDES
Local market intelligence	X		
International market intelligence	X		
Sustainability and compliance	X		
Proactive long-term decision making		X	
Reactive, short-term decision making		X	
Critical thinking		X	X
System thinking		X	
Risk thinking		X	
Adaptability to change		X	X

3.4.2 Competencies for circular sustainable purchasing

Having understood how circular economy and industrial symbiosis can impact the traditional role of a purchaser, the second sub-research question can be answered. To illustrate the myriad of changes, Table 3.5 has been designed.

Table 3.5: ASK for circular sustainable purchasing

		KNOWLEDGE	SKILLS	ATTITUDES
Circular economy	Knowledge Strategies (narrowing, slowing, closing loops)	X		
	Participation in activities related to CE Taking CE initiatives within an organisation Organisational citizenship behaviour	X		X
	Create synergistic partnerships		X	
Sustainability	Willingness to embrace sustainability Environmental awareness and education	X		X
New business models	Promote innovative, resource-efficient, circular supply chain solutions			X
Relationships with competitors and complementors	Build benefit-sharing schemas with suppliers Look at *coopetition* model (cooperate and compete)		X	X
Mentality	Foster innovation Long-term culture change			X
Tools and techniques	Lifecycle assessments Supply chain mapping Transparency tools Agreements Information sharing platforms Traceback management Agent-based modelling Risk monitoring and disruption strategies	X	X	
Design	Early involvement in design Design for longevity, reliability, and durability	X		X
	Technical standards Material literacy	X		
	Roadmap with budget holders		X	
Deal with uncertainty	Laws and regulation Compliance Resilience Region-specific knowledge Other industries knowledge	X	X	
Intrapreneurial	Proactive Explore and exploit the market Take risks Network		X	X
Balance	Cost versus sustainability Short versus long-term plans	X	X	

3.4.3 Competencies for technological advancements supporting sustainability

The competencies needed for a sustainable PSM professional, in case of technological advancements, are summarised in Table 3.6.

Table 3.6: ASK for technological advancements

	KNOWLEDGE	SKILLS	ATTITUDES
Automation	X		
Innovative sourcing	X		
Big data analytics	X		
Critical thinking		X	
Analytical		X	
Curiosity			X
Mobility			X

3.5 Conclusion on new competencies of PSM professionals in the dynamic environment of digitalisation, innovation, and sustainability

As the world quickly evolves and is being actively shaped by factors such as sustainability, digitalisation or innovation, the role of a purchaser unfolds. In terms of knowledge, skills and attitudes, new competencies are needed to perform strategic functions that are part of the new PSM tasks.

To answer the main research question, ***"What competencies must PSM professionals possess to effectively adapt to the dynamic environment of digitalisation, innovation, and sustainability?"*** the following Venn diagram, Figure 3.1, has been created.

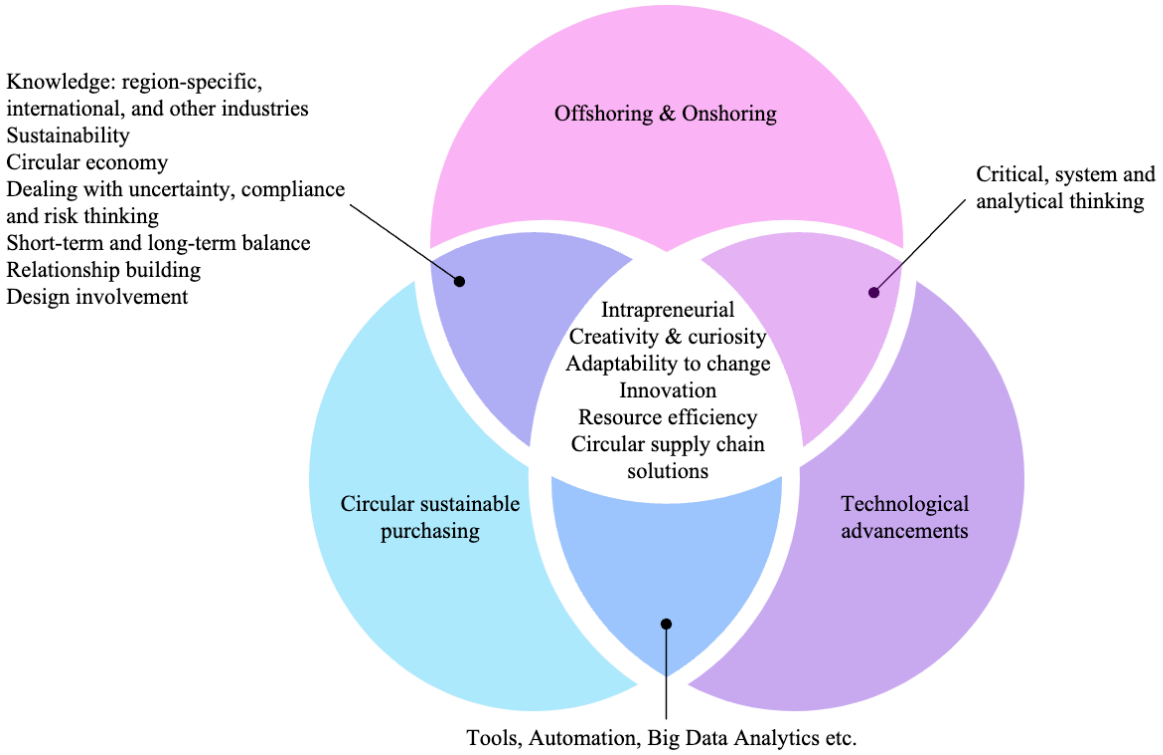

Figure 3.1 - New Competencies of PSM Professionals

Figure 3.1 captures the relationships between the three sub-research questions and shows the overlaps between the competencies discovered. At the figure's core resides the essence of a purchasing and

supply chain professional who can adapt to the dynamic environment characterised by trends such as innovation or sustainability.

Starting with the intersection between circular sustainable purchasing and off/onshoring, to become a boundary spanner, the purchaser must know about various domains, including understanding the region in which the organisation operates, having international market intelligence, and comprehending how other industries conduct their business. Moreover, the purchaser must be open to sustainable practices, be environmentally aware and try to promote and include a circular economy in the day-to-day operations. Regarding procurement and circularity of materials in design, the purchaser must also be involved in the design process from the beginning.

As the environment rapidly transforms, dealing with uncertainty and risks whilst being compliant is part of the required competencies. Creating a balance between short and long-term benefits is also a characteristic factor of a purchaser. One of the most essential elements which intertwine sustainable purchasing and off/onshoring is the capacity of an individual to network and build strong relationships with possible suppliers. As supply chains strive for resilience, or new connections between previously unrelated industries are being made with the help of industrial symbiosis, having good relationships with suppliers is pivotal for success.

To connect off/onshoring and technological advancements, critical, system, and analytical thinking are part of the array of competencies of a PSM professional. For example, the purchaser can reorganise or restructure current practices and design innovative or creative combinations of resources empowered by new technological advancements. This will make solving problems effective and help with making moral decisions or innovating, all whilst dealing with sustainability difficulties in a technical environment that is constantly evolving.

Considering circular sustainable purchasing and technological advancements, the PSM professional should be proficient in using new tools (e.g., information-sharing platforms) and leverage trends such as automation, big data analytics, and dashboarding that can boost the purchasing function.

Following the existing literature, the quintessence of a PSM professional can be delineated as a combination of intrapreneurship, creativity/curiosity, ability to change and innovate, circularity and resource efficiency. The purchaser must become proactive in exploring and exploiting the market. Taking risks and networking to gain a competitive edge is also crucial. As an attitude, the individual in purchasing and supply chain management should be creative and curious so that innovative solutions which can benefit the whole organisation can be discovered. Furthermore, as the market is shaped by sustainability, the PSM professional should be open to changes and inclined to learn more and apply the knowledge on circularity in their daily practices.

The intricate web of competencies of a professional in purchasing and supply chain management, discussed in this chapter, highlights how multifaceted the role of a purchaser is. Adapting to an ever-changing environment, which is now influenced by sustainability and technological developments, makes the purchaser a boundary-spanner. The most important competencies that enable one to be amidst the swiftly transforming environment include diverse knowledge, commitment to sustainability, risk management, supplier-building relationships and harnessing technological advancements. Thus, the professional in PSM should embody attributes such as intrapreneurship, creativity, flexibility, and commitment to change (e.g., circularity, resource efficiency) as they will enable the optimal execution of the strategic functions.

Chapter 4 - Sustainable Supply Chain Laws and Due Diligence

Max Mastebroek, Max Derwig and Eva Nelissen

Summary

The Corporate Sustainability Due Diligence Directive (CSDD) is essential to responsible and sustainable supply chain management in the increasingly globalised world. While the CSDD promises to benefit society and companies significantly, it also brings complicated challenges. Companies must prepare for this change and recognise the importance of transparency, compliance, and adaptability for their success. The directive's effectiveness depends on how effectively companies and regulators balance ethical responsibility and economic competitiveness. In doing so, the EU strives to create a global community where companies prioritise well-being and environmental sustainability.

4.1 The need for supply chain due diligence

Globalisation, characterised as the ongoing process of increasing interconnectedness among cross-border actors, driven primarily by the flows of people, ideas, goods and capital, has significantly changed the landscape in which companies operate and their interactions with the global community (Cassimon, Engelen, & Van Cappellen, 2018, p. 1). The phenomenon has led to immense economic growth and expansion opportunities but has also revealed several challenges and ethical dilemmas that demand attention (European Commission et al., 2020, p. 214).

For illustration, de Kluiver (2023, pp. 205-206) elaborated on how sustainability has gained importance in company discussions since the 2008 economic crisis. Several factors contributed to this shift, including the crisis, which raised questions about prioritising considerations beyond purely financial gains. This led to rethinking a sustainable economic model that considers all stakeholders and emphasises long-term results over short-term profits. Simultaneously, there has been an increased awareness of ecological constraints, such as environmental pollution, biodiversity loss, climate change, and human rights concerns. This awareness is exemplified by adopting the UN Guiding Principles on Business and Human Rights in 2011 and the European "Green Deal" in 2019 (de Kluiver, 2023, pp. 205-206).

In alignment with the Guiding Principles, national laws, such as the German *Lieferkettengesetz* of 2020, the French *Devoir du Vigilance* of 2017, and the Dutch *Wet Zorgplicht Kinderarbeid* of 2019 were introduced in response to the call for greater corporate responsibility and ethical business practices (Bagus, Daumann, & Follert, 2022, p. 1542; Bierbrauer, 2022, p. 344).

Nevertheless, as outlined by (Hoffmeister, 2022, p. 243), three main reasons remain for an EU-wide directive. Firstly, national laws come with drawbacks. For instance, due to varying obligations, national laws can distort competition within the EU's internal market. Secondly, potential "soft law" regulations appear to be insufficient. Lastly, an increasing global emphasis on supply chain responsibility and its implications for regulation within the EU legal framework

is evident, as EU member states, which are also OECD members, actively contributed to developing the 1976 OECD Guidelines. When the Human Rights Council adopted the UN Guiding Principles on Business and Human Rights in 2011, the OECD guidelines aligned with these UN standards. Also, the EU had already participated in negotiations on a binding international instrument on human rights, initiated by the UN Human Rights Council in 2014.

The European Commission has developed the Corporate Sustainability Due Diligence (CSDD) Directive in response to these challenges. The first question of this chapter is;

- "How does the EU CSDD Directive seek to revolutionise supply chain management to ensure resilience, efficiency and sustainability in an increasingly complex world?"

In addition, the report focuses on implementing the CSDD Directive and its implications for affected corporations. The second question of this chapter is;

- "What factors may influence corporations' integration of the CSDD Directive into their business strategy?"

4.2 The new CSDD Directive: its objective, key features, and enforcement

4.2.1 The desired impact

In the context of the CSDD Directive's aim of improving sustainability and ethical business practices, it is crucial to recognise the global scope of problems in supply chains. Figure 1 shows severe labour conditions in several countries, highlighting the urgency of addressing these challenges within supply chains.

The European Commission emphasises the significant role and objective of the CSDD as follows: "The behaviour of companies across all sectors of the economy is key to succeed in the Union's transition to a climate-neutral and green economy in line with the European Green Deal and in delivering on the UN Sustainable Development Goals, including on its human rights- and environment-related objectives" (Directorate-General for Justice and Consumers, 2022, p. 1).

These principles, articulated by the European Commission's Directorate-General for Justice and Consumers (2022, p. 1), underline the importance of several vital steps companies must take. Companies should develop detailed plans to minimise negative impacts on human rights and the environment in their supply chains. Furthermore, companies should integrate sustainability into how they manage and govern their operations, which implies incorporating factors such as human rights, climate change and their environmental footprint when making business decisions, as well as considering their long-term resilience.

The CSDD directive will provide numerous advantages for stakeholders in alignment with the principles. The directive focuses primarily on protecting human rights, including labour rights and working conditions. Furthermore, it promotes a healthier environment for both current and future generations. Additionally, the CSDD Directive aims to increase transparency in supply chains, which is expected to foster citizens' trust in these companies. Besides citizens, the directive aims to provide benefits for developed, but mainly for developing countries,

which are also expected to benefit from better protection of human rights and the environment.

In addition, there will be increased stakeholder analysis on critical sustainability issues in these countries. The CSDD Directive will motivate developing countries to invest in sustainability that enhances living conditions. From a company's perspective, the CSDD Directive offers several noteworthy benefits. As mentioned, increased transparency in the supply chain leads to greater customer trust while employees become more involved in their companies. This directive also ensures that companies become more aware of their negative impact on the environment and human rights (European Union, 2022, p. 1).

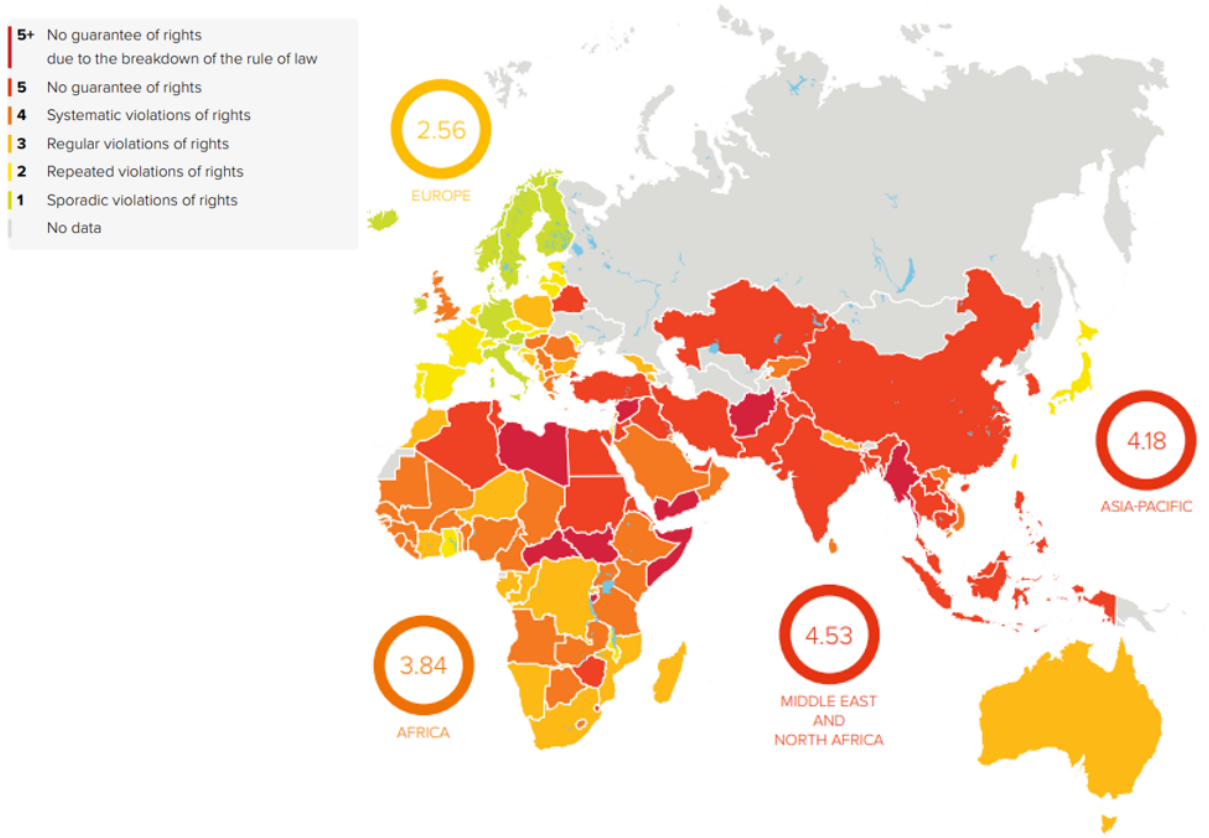

Figure 1. The violations of worker's rights ratings per country (International Trade Union Confederation, 2023, p. 15).

Furthermore, the CSDD Directive is expected to attract more excellent talent by attracting sustainability-oriented investors and public procurers. This, in turn, can encourage companies to explore innovative approaches to achieving the directive's objectives (European Union, 2022, p. 1).

In summary, the aim of the CSDD Directive can be described as to create a harmonised legal framework in the EU to create better protection for citizens, developing countries, and the environment while fostering ethical business practices, promoting sustainability, and encouraging transparency and responsibility in supply chains (Directorate-General for Justice and Consumers, 2022, p. 1).

4.2.2 Fundamental aspects

The CSDD Directive establishes a corporate due diligence duty. The core elements of this duty are identifying, bringing to an end, preventing, mitigating, and accounting for adverse human rights and environmental impacts in the company's operations, subsidiaries, and value chains (Directorate-General for Justice and Consumers, 2022, p. 3).

To achieve the objectives of the CSDD Directive elaborated in Section 4.2.1, companies must address the adverse impacts of their actions, including those in their value chains inside and outside of Europe. To facilitate this, supply chain transparency is essential. Supply chain transparency is "the extent to which all its stakeholders have a shared understanding of and access to, the product-related information that they request, without loss, noise, delay and distortion" (Hofstede, 2003, p. 18; Trienekens, Wognum, Beulens, & van der Vorst, 2012, p. 55).

To achieve supply chain transparency, companies must incorporate visibility and traceability (Morgan, Gabler, & Manhart, 2023, p. 1425). Supply chain visibility refers to "the visibility of demand and inventory information across the supply chain" (Somapa, Cools, & Dullaert, 2018, p. 308), while supply chain traceability is "tied to the operational aspects of a supply chain that support the ability to monitor current and historical system activities […] and is strongly influenced by technology" (Morgan et al., 2023, p. 1424).

Table 1: Affected Companies by the CSDD Directive, as taken from European Union (2022, p. 2).

		Large EU limited liability companies	Non-EU companies	Small and medium enterprises (SMEs)
Group 1	500+ employees and more than €150 million of turnover*	+/- 9,400 companies	+/- 2,600 companies	The proposed rules do not directly concern micro companies and small and medium enterprises. However, the proposal provides supporting measures for SMEs, which could be indirectly affected.
Group 2	250+ employees and more than €40 million of turnover*, operating in defined high-impact sectors such as textiles, agriculture, extraction of minerals. The rule will apply to this group 2 years later than to group 1.	+/- 3,400 companies	+/- 1,400 companies	
*Worldwide turnover for EU companies, and EU-wide turnover for non-EU companies				

In addition to providing transparent insights into the supply chain and its compliance with human rights and environmental standards, companies must align their business strategy with the regulations of the CSDD Directive. This strategic adjustment complies with the obligations introduced for directors of EU companies, who are responsible for setting up and overseeing the implementation of the due diligence processes and their integration. For instance, they

should align their strategy with the Paris Agreement, which aligns with the CSDD Directive. The main long-term objective of this agreement is to limit global warming to 1.5 °C. To achieve this, companies must reduce their greenhouse gas emissions, with transparency playing an essential role through frequent reporting of emissions (Directorate-General for Justice and Consumers, 2022, p. 4).

However, the directive does not impact all companies. Table 1 shows the directly and indirectly affected companies and the number of companies per category and group.

4.2.3 Rule enforcement and incentives

To ensure compliance, EU Member States will appoint an authority responsible for supervising and enforcing sanctions, including fines and compliance orders. In addition, the Commission will establish a European Network of Supervisory Authorities, bringing together representatives of national authorities to ensure a coordinated approach to execution. Furthermore, Member States will take steps to guarantee that victims receive compensation for any harm caused by non-compliance with the obligations, as outlined in the new proposal (European Union, 2022, p. 2).

The CSDD Directive presents objectives for company directors that must cohere with the regulations, as their primary responsibility falls to them. The directors will be stimulated by variable remuneration to contribute to achieving the objectives, for instance, when reaching the goals of the emission reduction plan (European Commission et al., 2020, p. 41). Companies must anticipate and prepare the new directive, which is expected to become active at the end of 2024 (Directorate-General for Justice and Consumers, 2022, p. 9).

4.3 Complexities and implications of the implementation: supply chain transparency, sourcing strategies, costs, and implementation support

4.3.1 Supply chain transparency

For a successful CSDD Directive implementation, companies need to analyse their supply chain before the CSDD Directive can be introduced. The expectations of the directive and their application to specific operations and supply chains must be fully understood.

As mentioned in section 4.2.2, companies must ensure complete supply chain transparency to find possible compliance with the regulations and act upon them. However, supply chains currently lack clarity due to their high complexity (Kalaiarasan, Olhager, Agrawal, & Wiktorsson, 2022, p. 8), and the visibility of suppliers is often limited to first-tier suppliers (B. Shao, Choi, & Shi, 2022). Achieving supply chain transparency can be challenging, time-consuming, and costly.

To address the complex issue of supply chain transparency and to be prepared for the implications of the CSDD Directive, it is crucial to elaborate on the structure of supply chains and their critical elements, including so-called nexus suppliers. Understanding their importance, as nexus suppliers have considerable influence within multi-layered supply networks, is essential for companies looking to improve supply chain resilience, CSDD compliance, and profitability (T. Y. Choi, Shao, & Shi, 2015). A nexus supplier is “any supplier in

a multitiered supply network that potentially exerts a profound impact on a buyer's performance due to its network position" (Yan, Choi, Kim, & Yang, 2015).

For instance, when a nexus supplier fails to perform, the supply chain is expected to become disrupted. Therefore, knowledge about nexus suppliers is essential in strategic decision-making concerning the supply chain. This knowledge can fuel supply chain resilience (F. Bowen & Siegler, 2023), which is part of the main CSDD Directive objectives (Directorate-General for Justice and Consumers, 2022, p. 1). To realise the visibility of nexus suppliers, directors must utilise the *Nexus Supplier Index* (NSI) to identify them within their multitier supply chains (B. B. M. Shao, Shi, Choi, & Chae, 2018). Furthermore, the NSI can expand the scope of ripple effects in supply chain risk analysis by including hidden suppliers in the models (Kinra, Ivanov, Das, & Dolgui, 2019), which also become visible. The approach is expected to lead to supply chains complying with the Directive and new supply chains that are more resilient.

Another more advanced, futuristic method of realising transparency within supply chains is the use of Industry 4.0 technologies (Delke, Karttunen, Kelly, Stek, & Tkáč, 2021; Delke, Schiele, & Buchholz, 2023; Delke, Schiele, Buchholz, & Stek, 2021). Blockchain is one example of a suitable Industry 4.0 technology (Hofmann & Rüsch, 2017, p. 25). It can be defined as "a distributed database, which is shared among and agreed upon in a peer-to-peer network. It consists of a linked sequence of blocks, holding timestamped transactions secured by public-key cryptography and verified by the network community. Once an element is appended to the blockchain, it cannot be altered, turning a blockchain into an immutable record of past activity" (Seebacher & Schüritz, 2017, p. 14). Visualising transaction histories and their imitability make blockchain technology exciting for the enhanced CSDD implementation (Felbermayr, Godart, Langhammer, & Sandkamp, 2021, p. 17).

Blockchain knows various characteristics and areas of application (Seebacher & Schüritz, 2017, p. 15). For illustration, M.-J. Yao, Lin, Lee, and Wang (2021, p. 2196) suggested using blockchain technology to coordinate the payment structure in multi-echelon supply chains. Smart contracts are identified as a critical blockchain technology that can be used for order processing, which is an essential function of operations and supply chain management (OSCM) (Grida & Mostafa, 2022, p. 660). Thereby, smart contracts can ensure the availability of sufficient funds for the transaction under consideration and that all parties are paid promptly (Sikorski, Haughton, & Kraft, 2017, p. 237).

After achieving supply chain transparency and the supply chain analysis, a risk assessment should be conducted to identify any existing issues with the new regulations, followed by creating an action plan to mitigate potential risks.

Moreover, supply chain transparency provides both citizens and other companies insight into the performance of the companies concerning the CSDD objectives. Thereby, companies can build more customer trust and trust from buyers in a business-to-business environment (European Union, 2022, p. 1).

4.3.2 Sourcing strategies

After achieving supply chain transparency, the CSDD Directive might require companies to (re)consider their sourcing strategies. Felbermayr et al. (2021, p. 14) state that some

companies may maintain their current sourcing practices only if they can guarantee compliance with the new regulations. Another option for companies is to consider sourcing from other sustainable suppliers abroad, which may result in a smaller supplier base and increased costs. The last alternative is reshoring, which involves moving production previously sourced from abroad back to the company's home country (Wiesmann, Snoei, Hilletofth, & Eriksson, 2017, p. 22). However, this could mean losing the cost advantages of cheaper production locations and the benefits of international division of labour. Consequently, global sourcing can be expected to decline (De Propris & Bailey, 2020, p. 167). It is important to note that all of these approaches rely on the availability of alternatives to the original suppliers (Felbermayr et al., 2021, p. 14).

4.3.3 The impact on costs and competitiveness

The choice of a company's strategy depends on various factors, including the industry, strategy, and the country in which the company is situated. It is essential to note that implementing the CSDD Directive is expected to increase (trade) costs (Felbermayr et al., 2021, p. 15). Companies subject to the directive can expect a cost increase. In contrast, companies in other countries or regions may not face the same cost escalation due to differences in their supply chain structures. This discrepancy may lead to a deterioration in the competitiveness of companies that must comply with the new directive (Godart, Görg, & Görlich, 2010, p. 7). Not only does the directive lose a competitive position to specific companies, but it also reduces the number of suppliers. This makes companies more vulnerable since they depend significantly on a limited number of suppliers. This, in turn, is inconsistent with the goal of the EU, which, especially after the financial crisis, calls for becoming independent of individual suppliers (Felbermayr et al., 2021, p. 9).

Furthermore, monitoring costs are expected to increase, affecting operational costs and causing suppliers to incur higher expenses. This will likely lead to decreased cost advantages for importing goods (Felbermayr et al., 2021, p. 14).

Additionally, the change in suppliers can be expected to result in additional costs in terms of time, money, and effort (Taherdoost & Brard, 2019, p. 8). If a company is forced to change supplier due to the inability of the current supplier to adhere to the CSDD Directive, additional cost occurs in many forms. The selection process itself can be time-consuming and, therefore, costly (Taherdoost & Brard, 2019, p. 1). Furthermore, as new suppliers can be unknown and new partnerships with the new suppliers need to be established, the quality of the received products might not be of the standard that the company generally aims for, which could result in Cost of Poor Quality (COPQ) (Alsada & Kumar, 2022, p. 3). Therefore, these additional expenditures can also be considered undesirable consequences of the CSDD Directive.

Predicting the exact costs of implementing the new directive is generally difficult. It is, as mentioned before, expected that companies will have to make significant investments to adapt to the directive, and it can be expected that the costs will eventually be passed on to their customers (Felbermayr et al., 2021, p. 29). However, these are still speculative concerns as the directive is not yet in force.

4.3.4 Implementation support

Companies could also seek additional third-party support by hiring compliance professionals to comply with the CSDD Directive. Compliance professionals can be employed to, for instance, monitor the company's compliance with the CSDD Directive (Homann, 2022). However, due to the extensive tasks involved, hiring a compliance professional alone cannot guarantee fulfilling a company's obligations. The tasks range from assessing the national and international legal framework to setting corporate standards, implementing an internal set of rules, monitoring compliance standards, training employees, and communicating the measures. To ensure comprehensive compliance in the company and its active enforcement, introducing a compliance management system (CMS) can be essential (Homann, 2022).

4.4 Contradictory effects and EU's compliance measuring challenges

4.4.1 Contradictory effects

Section 4.3.2 elaborates on potential shifts in sourcing strategies. However, whether the change will eventually have the desired ethical effect can be debated. For instance, in some countries, child labour is prevalent as families need to let their children work to survive (Bagus et al., 2022, p. 1546). For illustration, similar cases occur in Turkey among Syrian refugee children. The children must work in farms, sewing and carpentry workshops, cafeterias and restaurants, construction, and factories (Yalçin, 2016, p. 95). Yalçin (2016, p. 95) conducted a study regarding working conditions and the well-being of child workers and found that 24% of interviewed children were the primary earners of their families. Once sourcing practices are changed due to the CSDD Directive, families will likely face hunger and homelessness. This could lead to a scenario in which European supply chains comply with the EU's standards. Still, non-European countries whose standard of living differs from the EU average could suffer from the unintended effects of these new rules survive (Bagus et al., 2022, p. 1546). The example of the Syrian child workers illustrates that cultural differences and the Eurocentric approach of the CSDD Directive can be expected to cause ethical dilemmas and cultural conflicts.

In addition, as previously explained, companies may be forced by the CSDD regulations to search for alternative suppliers and possibly distance themselves from certain countries due to their failure to meet the CSDD requirements. This exemplifies one possible consequence of the CSDD Directive with far-reaching economic and global geopolitics implications. Therefore, it is possible that especially major economies, such as the US and China, may react to the EU's initiative. However, this issue is beyond the scope of this chapter and will therefore not be further elaborated.

4.4.2 Measuring efforts and compliance

Because directors will receive a variable remuneration for their efforts in complying with the directive, as elaborated in section 4.2.3, the remuneration has to be predetermined when implementing the directive (European Commission et al., 2020, p. 41). However, it is uncertain how these efforts of directors will be measured. It can be complex and challenging, as all companies have different business strategies and an extra level of adaptability for the new rule enforcement. Measuring the performance of approximately 13,000 companies (European Commission et al., 2020, p. 16) is a complex task that can barely be managed. Furthermore,

when directors do not have a good conception of how many financial incentives they will receive, they are expected to be less motivated to pursue the objectives set by the directive.

Another issue that might withhold directors from complying with the CSDD Directive's rules is that they must share insights into their supply chain. Some companies' unique supply chains offer a competitive advantage over other competitors. Once the specifics of these supply chains are revealed, their competitive edge on the market is at risk of being lost. It can be challenging for directors to determine the cost of making these supply chains more transparent. Because it is hard to decide whether the net effect of the directive is advantageous, directors might rather have conservative views towards the CSDD Directive (Thompson & Rust, 2023, p. 2).

Besides the companies, the supply chains must be analysed by third parties to guarantee that the companies have improved or are still in compliance with the new rules. Subsequently, monitoring is expected to cost a lot of time and resources for the European Commission (European Commission et al., 2020, p. 7).

4.5 Conclusion: the CSDD Directive: good intentions, tough implementation

Globalisation, characterised by the increased interconnectedness of cross-border actors (Cassimon et al., 2018, p. 1), has changed the world in which businesses operate. The resulting flow of people, ideas, goods, and capital has opened up new economic opportunities and revealed urgent challenges and ethical dilemmas. The need for corporate responsibility and ethical business practices has become increasingly evident in global crises, such as the 2008 economic downturn (de Kluiver, 2023, pp. 205-206). The shift has led to re-evaluating business models prioritising stakeholders' well-being over short-term profits.

In addition, concerns about environmental constraints such as climate change, biodiversity loss, pollution and human rights issues have increased significantly, as shown by the adoption of the UN Guiding Principles on Business and Human Rights and the European Green Deal (de Kluiver, 2023, pp. 205-206). National laws such as the German *Lieferkettengesetz*, the French *Devoir du Vigilance* and the Dutch *Wet Zorgplicht Kinderarbeid* have been passed to address these issues and emphasise the need for an increased corporate responsibility (Bagus et al., 2022, p. 1542; Bierbrauer, 2022, p. 344).

However, national laws also bring challenges. The European Commission has developed the Corporate Sustainability Due Diligence (CSDD) Directive in response to the challenges. The first question was related to how the CCSD Directive aims to revolutionise supply chain management to ensure resilience, efficiency, and sustainability. The directive is a comprehensive legal framework that addresses supply chain management's complexities and ethical concerns. It highlights the importance of companies in achieving the goals of the European Green Deal and the UN Sustainable Development Goals, including human rights and environmental sustainability. Companies must develop detailed plans to minimise negative impacts on human rights and the environment and integrate sustainability into their decision-making processes. The directive is intended to benefit citizens, developing countries, and companies. It promises a healthier environment, better living conditions and better

stakeholder analysis by promoting sustainability and responsibility throughout the supply chain (Directorate-General for Justice and Consumers, 2022, p. 1; European Union, 2022, p. 1).

The second question was related to the factors expected to influence the integration of the CSDD policy into companies' business strategies. Integrating the CSDD Directive into business strategies will depend on several factors. Supply chain transparency is critical; supply chain visibility and traceability are essential. Furthermore, companies must align their strategy with obligations under the directive, such as the Paris Agreement, which aims to limit global warming (Directorate-General for Justice and Consumers, 2022, p. 4). However, not all companies within the EU will be directly affected; the directive will specifically affect only various categories of companies (European Union, 2022, p. 2).

EU Member States and a network of regulators will monitor the enforcement of the CSDD Directive. To motivate company directors, variable remuneration will be introduced, linked to the objectives of the directive (European Commission et al., 2020). However, given companies' diversity and adaptability, measuring compliance is expected to take time and effort.

As the CSDD Directive progresses, it may lead to conflicting effects. Changes in sourcing practices may affect less developed countries, leading to ethical dilemmas (Bagus et al., 2022, p. 1546). Additionally, the implementation may lead to shifts in global economic and geopolitical dynamics.

The CSDD Directive is crucial to sustainable and responsible supply chain management during profound globalisation. While the directive promises many benefits for society and companies, it brings complexity and challenges. Companies must prepare for this shift and understand that transparency, compliance, and adaptability will be crucial to success. The success of its implementation will depend on the ability of companies and regulators to find the right balance between ethical responsibility and economic competitiveness. In pursuit of its goal, the EU aims to foster a global community where companies consider all stakeholders' well-being and the environment's preservation.

Chapter 5 - Inclusive, social sustainability in purchasing and supply management

Babette de Brouwer, Oscar Viladrich Beiroa and Timo Looms

Summary

Both social sustainability and supply chain resilience are essential factors in supply chain performance. No clear link is researched between social sustainability and supply chain resilience in the literature. Therefore, this chapter will explain how companies can improve their resilience in the supply chain while considering social sustainability. We recommend that companies focus on social sustainability practices from the literature review as they can moderate the effect of supply chain risk practices on integration and ultimately improve supply chain performance. Furthermore, companies should implement specific governance mechanisms through purchasing capabilities; companies can improve supply chain resilience alongside social sustainability.

5.1. Introduction to social sustainability in supply chains

5.1.1 Social sustainability in supply chains

With globalisation, companies have increasingly depended on offshore production for cheap labour. Human rights and labour scandals forced companies to take corrective measures, and social sustainability has been a much-discussed topic (Bubicz, Barbosa-Povoa, & Carvalho, 2021). Social sustainability can be defined as the impact of systems, activities, processes and organisations on people and the planet.

Implementing social sustainability in supplier locations enhances buyers' supply chain performance. It can reduce supply risks and improve the reputation in emerging economies (Mani, Gunasekaran, & Delgado, 2018). Furthermore, social responsibility in supply chains could moderate the relationship between risk management and supply chain performance (Duong & Ha, 2021). Therefore, it could benefit companies to focus more on social sustainability rather than just a necessity for corporate identity.

This chapter identifies social issues within supply chains by the following categories: equity, ethics, health and welfare, human rights, philanthropy and safety, as explained by (Fernando, Halili, Tseng, Tseng, & Lim, 2022). Section 0 provides more detail on these social issues. To improve social performance on the social issues within supply chains, firms adopt so-called governance mechanisms to manage the firm's relationships. In this context, governance mechanisms are ways companies manage relationships with other supply chain actors to improve their social performance, which will be further explained in Section 0.

Silva, Fritz, Seuring, and Matos (2023) and Silva and Ruel (2022) mention that supply chain resilience and social sustainability are significantly linked subjects for the purchasing department. Therefore, this chapter describes how companies can improve supply chain resilience while considering their social sustainability.

5.1.2. Supply chain resilience

SAP (n.d.) states that supply chain resilience is "the ability to respond quickly to operational disruptions through flexible contingency planning and forecasting- from material sourcing to logistics and the final delivery of products and services" (SAP, n.d.). The supply chain should be able to forecast and anticipate disruptions and try to prevent these disruptions to be resilient.
Factors influencing supply chain resilience are labour shortages, inventory scarcity, political uncertainty, and inflation. SAP proposes four methods for supply chain resilience. The first is to optimise production by using supply chain planning. All components in the supply chain are synchronised with supply chain planning, which results in visibility and agility. The second is to understand and leverage data. Analysing data improves the supply chain resilience. The third point is working in a supply chain with suppliers and manufacturing partners. This makes the supply chain less reliant on social, environmental, and political stability. The fourth method is implementing capacity and inventory buffers in the supply chain. Buffers make the supply chain less disrupted when something happens (SAP, n.d.).

Resilience strategies can be divided into two categories: proactive and reactive. Proactive means handling takes place before a disruption happens. This is done by planning and designing the supply chain to respond to disruptions. Reactive means reacting after a disruption has occurred. This is done by identifying risk sources and impacts (de Farias, dos Santos Alvim, de Simas, & Frazzon, 2022).

5.1.3. Importance of research

Both sustainability and resilience are critical for the supply chain. Firstly, due to tighter regulations, supply chains are asked to ensure ethical practices such as fair wages, ethical sourcing, and good working conditions. This becomes even more challenging in a highly globalised era where outsourcing can be complex. Similarly, consumers are placing greater emphasis on sustainability, which creates extra pressure on businesses. Therefore, incorporating social sustainability is becoming a competitive advantage in the market.

Moreover, having a resilient supply chain is crucial for risk management. Disruptions like the COVID-19 pandemic or the war in Ukraine highlighted the need for supply chain resiliency where resilient practices minimise uncertainty in demands.

The question of how companies balance their social sustainability practices with their ability to have a resilient supply chain still needs to be clarified. Social sustainability and resiliency in the supply chain have been discussed separately, while only recent literature focuses on their integration. This chapter showcases how achieving the goals of social sustainability and supply chain resilience can be aligned.

5.1.4. Potential relationship diagram

A relationship diagram supports the analysis of the relationships to determine the structure and topics discussed in this book chapter. The goal of Chapter 5 is to describe how companies could improve their supply chain resilience while considering social sustainability. Therefore, the diagram illustrates potential social sustainability and supply chain resilience relationships.

As illustrated in **Error! Reference source not found.**, social performance could affect supply chain r esilience in two ways. Firstly, it can directly influence supply chain resilience, showing that an inclusive purchasing program positively contributes to supply chain resilience (Silva & Ruel, 2022). Secondly, social performance moderates the relationship between supply chain risk management practices and supply chain performance (Duong & Ha, 2021).

Furthermore, supply chain risk management practices directly influence supply chain resilience, as supply chain risk management is adopted to improve supply chain resilience.

As seen in **Error! Reference source not found.** governance mechanisms are adopted to improve social p erformance (de Morais & Barbieri, 2018). This will be the primary method analysed to enhance social performance directly.

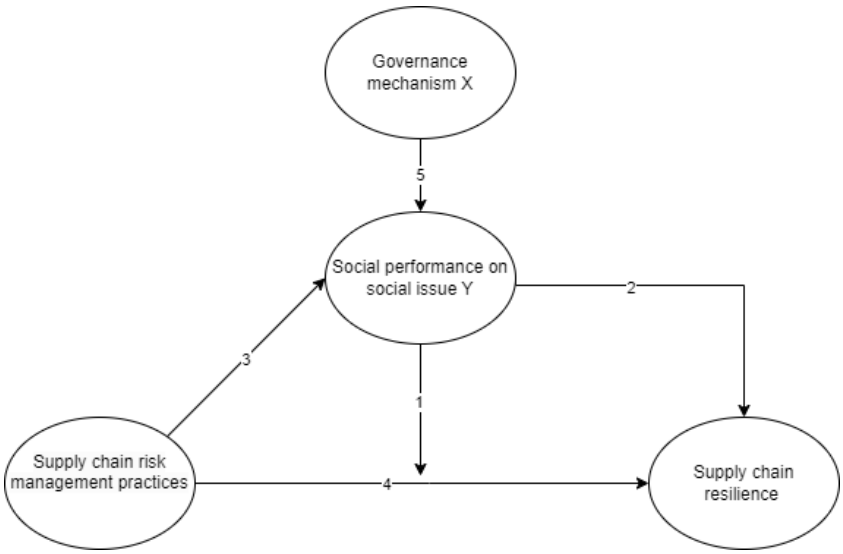

Figure 2: potential relationship diagram

- Relationship 1: Social performance on social issue Y moderates the relationship between supply chain risk management practices and supply chain resilience.
- Relationship 2: Social performance on social issue Y directly influences supply chain resilience.
- Relationship 3: Supply chain risk management influences social performance on social issue Y.
- Relationship 4: Supply chain risk management influences supply chain resilience.
- Relationship 5: Governance mechanism X affects the social performance on social issue Y.

The relationship diagram supports establishing which relationships to analyse and will be used as a basis for the research questions.

5.1.5. Research questions

This book chapter identifies ways companies can improve their supply chain resilience and social performance. This chapter focuses on governance mechanisms (de Morais & Barbieri, 2018) and supply chain risk management practices (de Morais & Barbieri, 2018) as potential solutions. It also analyses how the two topics are interrelated and which other relationships potentially play a role. Based on the possible relationship diagram, this chapter introduces how companies improve their supply chain resilience while considering their social sustainability. For this, the following main research question will be answered:

How can companies improve their supply chain resilience while considering social sustainability/social performance?

With the following sub-research questions, each of the relationships in the potential relationship diagram can be analysed. This finds how governance mechanisms and supply chain risk management practices can improve social performance and supply chain resilience.

1. What is the link between social sustainability and supply chain resilience?
2. What is the relationship between supply chain risk management and social performance?
3. What are governance mechanisms?
4. How could governance mechanisms affect social performance?

The sub-research questions outline the structure of this book chapter and are the topics of the subsection(s) in this chapter.

5.2. What is the link between social sustainability and supply chain resilience?

Tundys and Wiśniewski (2023) research which elements of the triple bottom line (social, environmental, and economic) are used to build sustainable supply chain resilience. By conducting survey questionnaires, the conclusion is drawn that individual sustainability factors influence supply chain resilience. From the research, all three aspects of the triple bottom line influence supply chain resilience. However, from all aspects, social sustainability has the least impact on supply chain resilience, with a significance of 10%.

Zhu and Wu (2022) investigate the relationship between supply chain resilience (SCR) and supply chain performance with the mediating effect of sustainability. The researchers had the assumption that SCR is an essential condition for supply chain sustainability (SCS) and that SCR is vital to improving SCS and SCP. The research conducted surveys to collect data from enterprises to test the relationships between these elements. The study had the following results:

- Supply chain resilience has a positive effect on social sustainability, environmental sustainability, and economic sustainability. (H1, H2 and H3)
- Supply chain sustainability has a positive effect on supply chain performance. (H4, H5, H6)
- Supply chain resilience has no direct positive effect on supply chain performance. (H7)
- Economic, social, and environmental sustainability play an intermediary role in the effect of supply chain resilience on supply chain performance. (H8, H9, H10)

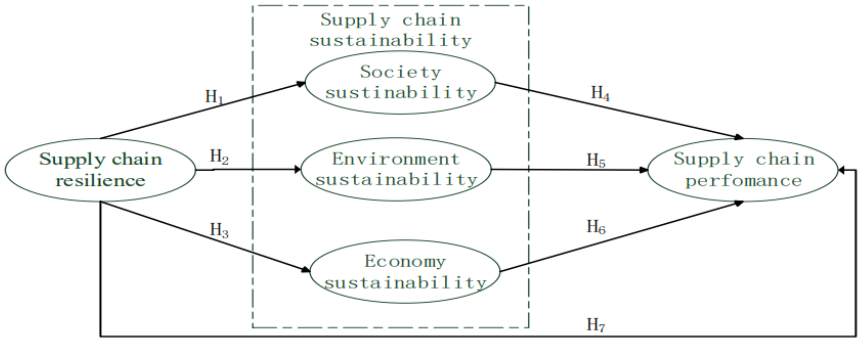

Figure 3 - hypotheses (Zhu & Wu, 2022)

Betto, Zangiacomi, and Fornasiero (2023) identify the most critical social sustainability risks and what makes the supply chain vulnerable. After that, it researches how the resiliency capability collaboration helps supply chains to reduce these risks. Collaboration is seen as one of the most critical capabilities of supply chain resilience.

From a systematic literature review, the research segmented social trends that lead to risks for supply chain resilience into three categories: demographic change, urbanisation, and consumption patterns. These risks are decreasing functional capacities, knowledge loss, lack of skills and few training opportunities, weak or missing control over workers' rights, poor working conditions, lack of stakeholders' involvement, lack of interest in working conditions, and social sustainability introduction-related risks.

To prevent these risks, Betto et al. (2023) propose collaboration as part of supply chain resilience to reduce supply chain disruptions. The paper presents four types of cooperation to indicate which actors should be involved: Internal, Supplier, Consumer, and Society.

Betto et al. (2023) propose different activities in collaboration: sharing information, resources, costs, risks and benefits, joint knowledge creation, collaborative communication, synchronising decisions, and goal congruence.

The previous literature review links social sustainability and supply chain resilience. Literature has shown that there could be a positive relationship between social sustainability and supply chain resilience. If social sustainability improves, supply chain resilience improves as well. The big question remains: what aspects of social sustainability can help to improve supply chain resilience?

Silva and Ruel (2022) research how social sustainability affects supply chain resilience and the role of purchasing for supply chain resilience. The paper suggests that the purchasing department of a company has the opportunity to boost supply chain resilience. One of the conclusions is that social sustainability will enhance supply chain resilience if purchasing capabilities are highly developed and spread among supply chain members.

Purchasing capabilities and supply chain resilience

The purchasing capabilities mentioned by Silva and Ruel (2022) are collaboration, financial strength, adaptability, visibility, and empowerment. Companies prioritising social sustainability perform better on the capability factors and can enhance their supply chain resilience through these factors, as depicted in Figure 4. This implies that companies can simultaneously improve supply chain resilience and social sustainability through improving the mentioned capabilities.

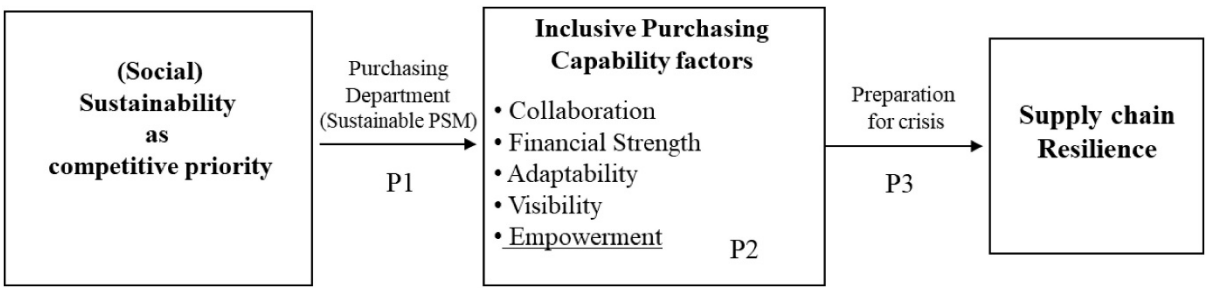

Figure 4: the role of capabilities between social sustainability and supply chain resilience (Silva & Ruel, 2022)

Betto et al. (2023) mention that collaboration in a supply chain can improve the supply chain's resilience. This collaboration also entails sharing information, joint knowledge creation and collaborative communication. These aspects can be summarised into visibility in the supply chain. As can be seen from Figure 4, multiple purchasing capability factors influence supply chain resilience. As collaboration and visibility are mentioned by other sources in the previous literature review section, these will be further researched. Visibility will be discussed in this section. Collaboration will be discussed in Sections 5.4 and 5.5.

Visibility can be described as the status of knowledge of current operational resources in the supply chain and its environment. Supply chain visibility can help reduce risks and disruptions in a supply chain. Therefore, supply chain visibility can improve supply chain resilience (de Farias et al., 2022). For example, visibility gives insights into the company's supply processes, making it easier to predict disruptions or see what needs to be done when a disorder occurs. In addition, visibility enhances the supply chain responses, making it faster to act upon disturbances. To summarise, visibility improves decision-making, responsiveness, and the organisation's performance by reducing the chances of disruptions and their impact.

Sunmola et al. (2023) also mention that supply chain visibility is essential for supply chain resilience. Their paper identified factors that influence supply chain visibility. These factors are prioritised according to two perspectives: the digital technology perspective and the supply chain relationship perspective. The key factors that drive visibility are responsible sourcing, supply base management, price advantage, purchasing power, compliance, customer service, market intelligence and modular design (Sunmola et al., 2023).

5.3. What is the relationship between supply chain risk management and social performance?

Supply chain risk management is "the management of supply chain risks through coordination or collaboration among the supply chain partners to ensure profitability and continuity" (C. S. Tang, 2006). The main phases of supply chain risk management include risk identification, risk assessment, risk mitigation and monitoring. During the first phase, potential risks are identified, and then during the second phase, risks are evaluated and classified. In the risk mitigation phase, strategies to mitigate risk are proposed, and finally, the risk is monitored in the last stage.

Firm social performance refers to a company's capabilities to achieve social goals and maintain ethical business practices. Fernando et al. (2022) conceptualise a firm's social performance in six domains: equity, ethics, health and welfare, human rights, philanthropy, and safety.

Table 1: Overview of social performance in firms (Fernando et al., 2022)

Component	Description
Equity	Involves compliance with employee health, safety, social conditions, and equity requirements. Emphasizing diversity and ensuring equal opportunities without discrimination based on gender, income, ethnicity, or other factors is crucial for supply chain sustainability.

Ethics	Ethics in firm social performance involves adhering to moral judgments about right and wrong based on social values, norms, and beliefs
Health and Welfare	Health and welfare in a firm social performance focus on prioritising employees' overall health and well-being. Compliance with health and safety standards, prevention of occupational injuries, and ensuring proper hygiene and health standards for employees are integral.
Human rights	Human rights for all individuals involved in the supply chain, including employees and communities.
Philanthropy	Involves acts of goodness and contributing to the well-being of society.
Safety	It involves prioritising the safety of both internal and external stakeholders, including employees and customers. Adhering to occupational safety and health standards and ensuring the safety of products is crucial for a company's social responsibility.

Duong and Ha (2021) explore the relationship between supply chain risk management and supply chain performance through supply chain integration. The authors conceptualise supply chain integration as the link and collaboration between firms and partners. Supply chain integration has three aspects: supplier, customer, and internal integration. The study emphasises the importance of internal and external collaboration, driven by effective risk management, in achieving a higher level of supply chain integration and improved supply chain performance. Additionally, the authors investigate the moderating effect of supply chain social sustainability in the relationship between supply chain risk management and integration.

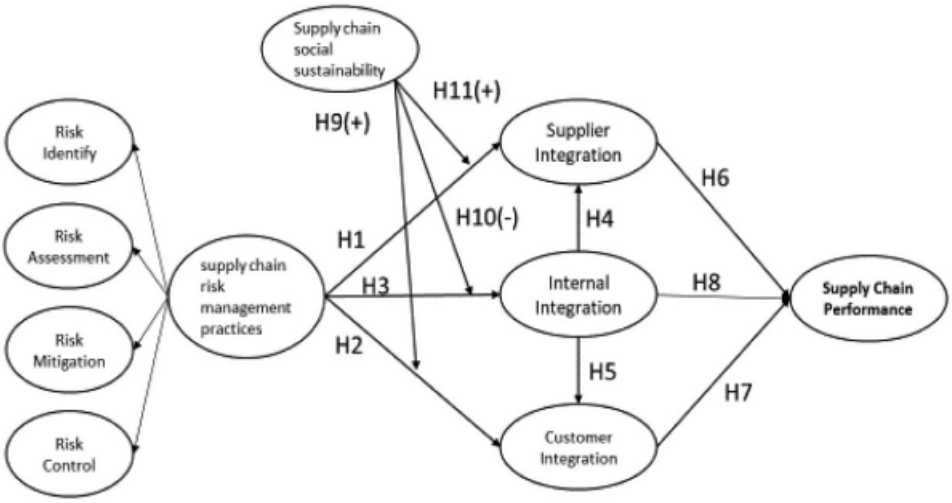

Figure 5: Hypotheses (Duong & Ha, 2021)

The findings highlighted the positive impact of supply chain risk management on integration and emphasised that exchanging information with suppliers and customers enhances operational performance. Next, a moderating effect of supply chain social sustainability in the relationship between risk management and integration was found. More precisely:

Supply chain social sustainability significantly enhances the impact of supply chain risk management on customer integration (H9+). Encouraging social sustainability values within the organisation positively influences customer cooperation and helps overcome risk issues.

Risk management practices substantially impact supplier and customer integration when coupled with social sustainability (H9-H11).

Social sustainability diminishes the impact of risk management on internal integration. Internal employees ' recognition of social sustainability incentives reduces the perceived importance of risk management for internal integration (H10).

5.4. What are governance mechanisms?

According to Gimenez and Sierra (2013), the definition of governance mechanisms is "the practices used by companies to manage relationships with their suppliers, to improve their sustainability performance". Formentini and Taticchi (2016) mention governance mechanisms to improve sustainability performance by managing relationships with supply chain actors. To summarise, governance mechanisms are methods by which companies ensure other companies within their supply chain operate sustainably following their goals.

Table 2: Overview of governance mechanisms for social sustainability (de Morais & Barbieri, 2018)

Governance mechanism	Description
Integration Activities and Internal Governance	These mechanisms include top management support; Use of codes of conduct/ethics, guides and internal policies; establishment of objectives, action plans and management systems; incentive systems and rewards for internal members; systematic analysis of the supply chain and classification of suppliers; adherence to international initiatives (e.g. Global Compact); Certifications (e.g.ISO14001)
Screening/selection of future suppliers	Definition of minimum standards required; Process defined for supplier selection
Incentive actions for improvement	Establishment of consequences for noncompliance; Contracts with reward system; Encouraging competition based on sustainable criteria
Assessment	Activities related to supplier assessment, such as application questionnaires or company visits.
Monitoring	It seeks to guarantee hiring expectations with audits or certification by an independent third party. It reports on success and how agreed practices are being implemented.
Collaboration	Better coordination with customers, suppliers and stakeholders to jointly improve results. May involve membership / Collaboration with NGOs; Collective initiatives (sectoral)
Development	Training and education; Joint development; Follow-up activities; Supplier diversity; Knowledge and shared assets; Knowledge transfer; Local Suppliers

Formentini and Taticchi (2016) define two main factors characterising governance mechanisms: collaboration and formalisation. Non-collaborative governance mechanisms use contractual power to ensure the cooperation of other supply chain actors. On the contrary, collaborative governance mechanisms are built upon working together to improve sustainability performance. Secondly, formalisation is the extent to which decisions and communication are done in a structured way (Alvarez, Pilbeam, & Wilding, 2010). In formal governance mechanisms, the governing company has complete

insight into the sustainability practices of supply chain actors, whereas informal governance mechanisms are built upon thrust.

Furthermore, Morcillo-Bellido and Duran-Heras (2020) classify governance mechanisms into direct and indirect governance mechanisms. Direct mechanisms involve that the focal company spends time and resources to manage sustainability improvements within its supply chain. In comparison, indirect mechanisms are based on third-party standards and do not require the time or resources of the focal company.

Concerning the social sustainability of supply chains, de Morais and Barbieri (2018) provide an overview of governance mechanisms based on existing literature. Error! Reference source not found. provides a n overview of these established governance mechanisms.

5.5. How could governance mechanisms affect social performance?

Firms seek to improve their social sustainability performance in their supply chain through contractual governance (Awan, Kraslawski, & Huiskonen, 2018). However, Awan et al. (2018) also mention that supply chain managers should collaborate with suppliers. Furthermore, within collaboration within global supply chains, employing cultural intelligence teams helps to adapt to cultural differences, can reduce interfirm conflict and shift the focus towards information exchange. Thus, it could improve social performance by preventing inefficient collaboration. Through collaboration, companies can enhance cooperation by enabling supply chain resilience improvement alongside improving their social sustainability (Silva & Ruel, 2022).

Buying companies use audits to ensure the agreed cooperation of all supply chain actors on sustainability. Companies use social and environmental auditing (SEA) (Castka, Searcy, & Mohr, 2020). SEA is a monitoring governance mechanism (de Morais & Barbieri, 2018). Audits can be very effective in ensuring collaboration and providing insights into where social issues, such as poor working conditions, arise, thus increasing visibility. Auditing could improve social performance on labour conditions, health and safety and fair wages (Castka et al., 2020). Furthermore, auditing can improve supply chain resilience by enhancing - in Section 0 mentioned - visibility capability (Silva & Ruel, 2022). Auditing can improve supply chain resilience. However, audits are also resource- and time-intensive (J. Y. Chen, Qi, & Dawande, 2020) and should only be used efficiently.

In selecting suppliers, social performance could be included in decision-making, such as by Neumueller Claudia, Neumueller, Lasch, and Kellner (2016), who had social performance as a factor within a multi-attribute decision-making model. Considering social sustainability in supplier selection would be a form of the “screening and selection of future suppliers” governance mechanism (de Morais & Barbieri, 2018). Purchasing managers often consider social sustainability as sustainability (including social sustainability) significantly impacts supplier evaluation (Zhan et al., 2021). This positive relation should motivate suppliers to improve their (social) sustainability practices, making them more likely to be chosen as suppliers and thus improve social performance.

As can be concluded from the examples, governance mechanisms can improve social performance in several ways. Thus enabling companies to ensure all supply chain actors are aligned with their social sustainability goals. Firstly, companies should include social sustainability in the selection decision-making process, providing a supply chain partner is aligned with their goals. Using contractual governance and collaboration, companies can provide complete awareness of the supply chain actors on the social sustainability goals. Companies should use auditing and other monitoring strategies to

check the participation in agreed-upon social sustainability practices. Figure 6 illustrates a company's potential steps to ensure social performance through governance mechanisms.

Figure 6: steps of governance for social sustainability

5.6. Conclusion

5.6.1. Answers to sub-research questions

- *What is the link between social sustainability and supply chain resilience?*

This literature review has shown a relationship between social sustainability and supply chain resilience. On one hand, supply chain resilience positively affects social sustainability. Social sustainability also plays an intermediary role in the effect of supply chain resilience on supply chain performance.

On the other hand, social sustainability can positively affect supply chain resilience. Betto et al. (2023) propose that collaboration, a part of social sustainability, can help improve supply chain resilience. This collaboration involves the different actors in the supply chain: internal actors, suppliers, consumers and society. Minelle E. Silva and Morgane M.C. Fritz (2023) conclude that the purchasing department, with highly developed capabilities, has a significant opportunity to improve supply chain resilience.

- *What is the relationship between supply chain risk management and social performance?*

Section 5.3 highlights that effective supply chain risk management positively affects supplier and customer integration, ultimately enhancing operational supply chain performance. The literature emphasises the need to integrate risk management and social sustainability values. It revealed how social sustainability moderates the relationship between supply chain risk management and integration, especially concerning customers and internal operations. Therefore, firms can include social sustainability practices in their current supply chain management to improve supply chain resilience.

- *What are governance mechanisms? How could governance mechanisms affect social performance?*

As defined in Section 0, governance mechanisms are: “the practices companies use to manage relationships with their suppliers, to improve their sustainability performance”. Governance mechanisms can be classified into two factors: collaboration and formalisation. These factors subsequently indicate whether the improvement in sustainability is based on building relationships or on contracts and how formal communication between the parties is done.

Our literature review provides several ways in which governance mechanisms could affect the social performance of companies. Section 0 gives several examples of how social performance can be affected by several types of governance mechanisms. Literature has shown that governance mechanisms should be adopted within supplier selection to achieve social sustainability goals. Contractual governance and collaboration should be adopted. Auditing or other monitoring strategies can ensure the participation of all supply chain actors.

Furthermore, through governance mechanisms, the purchasing capabilities collaboration and visibility can be improved, as shown in 0. As these capabilities positively affect supply chain resilience (Section 00), governance mechanisms can boost supply chain resilience alongside their social performance.

5.6.2. Answer to the main research question

Given the answers to the sub-research questions, a final answer to the original research questions is formulated. The research question is, “How can companies improve their supply chain resilience while considering social sustainability/social performance?”. To summarise our findings, companies should focus on social sustainability practices as they can moderate the effect of supply chain risk practices on integration and ultimately improve supply performance. Furthermore, companies should implement governance, as mentioned earlier, mechanisms through the purchasing capabilities. Companies can improve supply chain resilience alongside social sustainability.

Chapter 7. AI, Big Data Analytics and Machine Learning in Purchasing and Supply Chain Management

Sten Eijkholt and Ruben Gerhardus

Summary

This chapter explores the novel fields of Artificial intelligence (AI), big data analytics (BDA), and machine learning (ML) in purchasing and supply chain management (PSM). The literature study indicated a significant increase in publications regarding AI and ML. However, the publications display two principal remarkable distributions. Firstly, the research division in different industries is skewed towards grocery, food, automotive, and fashion. Secondly, the publications mainly elaborate on AI and ML substantively compared to the number of publications aimed at the application and the criteria involved. This chapter, therefore, highlights the role of AI and ML in purchasing management, exploring the current landscape and the potential it offers for future application. Furthermore, a framework of participation criteria indicates the critical factors required for applying AI and ML and examples of different techniques and applications.

7.1 Introduction

Procurement plays an essential role in a firm's strategy. Industrial companies purchase 60 to 80% of their turnover (Bals, Schulze, Kelly, & Stek, 2019b). Imagine harnessing the power of AI to improve operations in the rapidly evolving world of purchasing and supply chain management. The rapid development of new technologies in competitive markets requires companies to develop at an equal rate to remain competitive (Giannakis & Papadopoulos, 2016; Nguyen, Li, Spiegler, Ieromonachou, & Lin, 2018), especially in today's globalised economy. Economic events in recent years confirmed that the market is vulnerable to disturbance (MacKinlay, 1997). For instance, COVID-19, the war in Ukraine and the 2008 financial crisis significantly impacted the economy. Therefore, supply chains (SC) are sensitive to impact and must adapt to new circumstances. The effect of disruptions to the SC indicates that every improvement in risk management or decision-making in purchasing management (PM) must be explored. Careful decision-making is required to anticipate circumstances and adapt accordingly adequately.

Although experienced human decision-making has its advantages, it is widely acknowledged that Artificial Intelligence (AI) or Machine learning (ML) outperform human decision-making (Marr, 2016). The popularity of AI/ML increases among supply chain management (SCM). However, few publications discuss the industrial implementation or application of AI/ML in SCM (Ni, Xiao, & Lim, 2020). The lack of publications about implementation is suspected to be due to a lack of understanding or companies unprepared for significant adjustments. The lack of development is remarkable due to the data available for modern companies generated as a

(by) product of digitalisation. Furthermore, digitalisation increases accessibility to large datasets and is expected to be even more in the future (Ritter & Pedersen, 2020).

Regarding large datasets, human decision-making might be disadvantaged by abundant data. In contrast, the accuracy of AI/ML increases in efficiency, accuracy and reliability as the amount of data increases (OECD, 2021). Combining the availability of large datasets with the recent rise in popularity of AI/ML in research publications provides the potential of applying AI/ML in SCM, effectively optimising processes, and supporting PM. Therefore, combatting risk, maintaining a stable SC during economic disruptions and minimising human error (Tirkolaee, Sadeghi, Mooseloo, Vandchali, & Aeini, 2021).

7.1.1 Complication

Purchasing management makes up a significant portion of a company's strategy, although few publications extensively cover the applications for companies. The level of digitalisation, knowledge and data availability varies between businesses and industries. Therefore, the current applications are observed to be limited to companies with a more extensive research budget, high data availability, and a more significant SC dependence. However, this might not be necessary for purchasing management improvements through AI or ML applications. Literature indicates an increase in publications regarding AI and ML. Yet, few publications aim to explore the application or implication of AI and ML in purchasing management. This causes uncertainty for companies to adopt it and to find its usefulness. Therefore, an overview of available AI/ML technologies, advantages, and participation criteria is a desired addition to the body of literature. Consequently, access to a framework like the previously described offers companies the opportunity to make a well-considered choice to apply AI/ML.

7.1.2 Objective

This chapter provides a framework for the potential implications of AI/ML in PM and SCM. This framework aims to increase accessibility to AI/ML for the entire industry by focusing on broad application potential. This framework includes a summary of the potential advantages of implementing AI/ML in SCM in the industry. A list of criteria/requirements to be eligible for AI/ML (e.g., budget, data, expertise). Furthermore, this chapter aims to provide a framework for a company to determine whether the application is beneficial. Finally, examples of different AI/ML technologies and their applications are provided.

7.2 State of the Art

Computer-based assistance in SCM decision-making has been applied for many years now. However, its popularity is increasing as it assists in optimising operations. The computer algorithms use various datasets like shipment data, product life cycle data, ordering patterns, manufacturing data, et cetera. AI-enabled systems perform similar tasks. The difference is that AI can learn the possible combination of those algorithms and datasets to yield the most accurate prediction (Dash, McMurtrey, Rebman, & Kar, 2019). The current development of

AI/ML applications in the industry is limited. For example, National Grid in the UK uses Google's platform 'Deepmind' to improve SC decision-making (W. Yao, 2018).
Furthermore, German online retailer Otto reduced 90% of its inventory by an ML application to incorporate historical sales data, the setup of supply chains and near-real-time variables such as advertising campaigns, prices, and local weather forecasts. This allows Otto to rely entirely on AI without human interaction (Burgess & Burgess, 2018). Additionally, AI has also been widely applied in AI-enhanced logistics robots. These robots are fully autonomous and can integrate disturbances into their movement routines via an unsupervised learning engine (Webster & Ivanov, 2020). Although the list of example applications proceeds, the distribution of its current application per industry is remarkable. The research, development and application are found to be limited to larger organisations with a larger budget and workforce. Regarding the arguments mentioned in the previous paragraph, some industries benefit more from AI/ML than others. Thus far, this technological progress seems limited to the grocery, food, automotive and fashion industries.

7.2.1 Industrial Progress

The current trend in research on the application of AI/ML in SCM can be divided by industry to indicate the recent development and the contribution of each sector to the development. This information can also identify industries that stay behind in development. A remarkable observation from Figure 7 below is the skewness of the distribution. Additionally, the grocery and food industries dominate the AI/ML applications in SCM, closely followed by automotive and fashion.

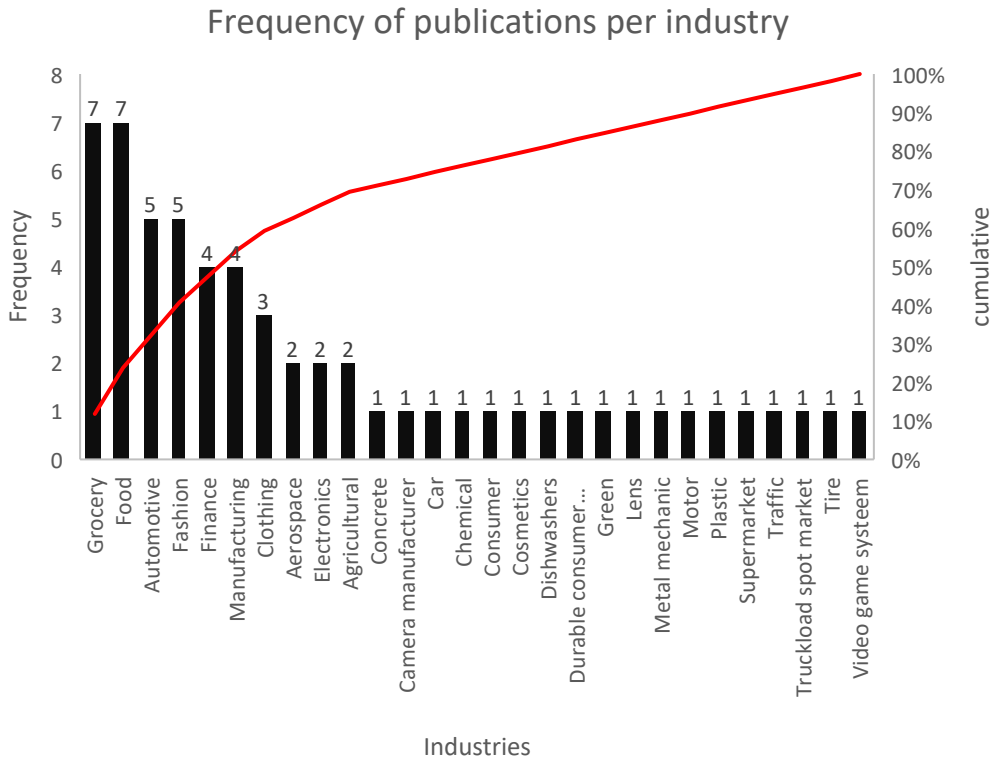

Figure 7, development classification per industry (Ni et al., 2020).

The distribution may result from the volume of products moving through the SC. Grocery and food are necessities of life and, therefore, occupy a significant market share. Logically, these industries might have higher requirements for their SCM and have a higher budget to invest in research. The application of AI/ML allows the food and grocery industry to maintain low inventory and operation costs. Furthermore, it is beneficial to food industries to optimise the efficiency of their logistic performance due to the relatively short shelf-life of their products (Ruteri & Xu, 2009).

7.2 Theoretical framework

This chapter provides a framework for the potential implications of AI/ML in PM and SCM. This chapter is divided into different sections to develop a clear framework. The first section consists of a formal introduction to artificial intelligence, creating the foundation of the context of AI in this chapter. Secondly, big data analytics and its subdivisions are described as a significant element of AI. Furthermore, this chapter includes a summary of examples and the potential advantages of implementing AI/ML in SCM in the entire industry. To conclude, an overview of eligibility requirements for AI/ML is provided, along with the required actions divided into steps.

7.2.1 Artificial intelligence

Artificial intelligence (AI) is an upcoming technology in the scientific literature space. More research is published each year on the topic (Ni et al., 2020). Quoting the definition of AI from Encyclopædia Britannica:

> *"Artificial intelligence (AI) is the ability of a computer or a robot controlled by a computer to do tasks that are usually done by humans because they require human intelligence and discernment" (Copeland, 2023).*

However, there is no consensus on the definition (Collins, Dennehy, Conboy, & Mikalef, 2021). The domain of AI consists of machine learning (ML), natural language programming (NLP), and artificial neural networks (ANN). It differs from more traditional algorithms in its level of intelligence. Where a conventional algorithm may successfully solve a problem, it can do so because it has been explicitly programmed to do that precisely. In contrast, an AI can solve a problem by 'learning' how to solve a problem, thus mimicking/approaching human intelligence (Maddula, 2021) (R. Y. Choi, Coyner, Kalpathy-Cramer, Chiang, & Campbell, 2020).

According to Ni et al. (2020), there is a significant discrepancy in the research on different ML techniques. The ten most published (from most published to least) techniques are Neural Networks (NN), Support Vector Machine (SVM), Logistic Regression (LR), Decision Tree (DT), Extreme Learning Machine (ELM), Naive Bayes Classifier (NBC), K-Nearest Neighbour (KNN), Random Forest (RF), Ensemble Algorithms (ESM) and K-means.

NN, SVM and LR cover over 75% of all selected papers. Therefore, the following section discusses the matter in depth. NN is a technique which aims to mimic the way humans learn. The NN consist of nodes which can "communicate" with other nodes via a connection. Based on the interaction level between nodes, their relationship is weighted. Nodes that are associated with each other thus have more robust connections. A network of nodes can vary

in depth. Simple networks have one to three levels, and deep networks can have hundreds of networks. The depth is usually correlated with the number of possible outcomes. The process can be seen as a black box, as only the input and output are known. It can identify complex non-linear relationships (Ni et al., 2020) (R. Y. Choi et al., 2020).

SVM is a technique that can classify data by finding a boundary between data points called a 'hyperplane'. It searches for the most significant boundary, which is the most optimal hyperplane. This hyperplane allows for later data classification to be done with more certainty. This allows for global optimums to be found (Gandhi, 2018; Ni et al., 2020)

LR is based on linear regression but is disguised by its ability to model non-linear relations. It used a non-linear equation to estimate the probability of classification. It can predict binary outcomes out of continuous or categorical predictors. However, it still depends on the chosen relation and thus can have poor fitness (LaValley, 2008) (Ni et al., 2020) (R. Y. Choi et al., 2020).

7.2.2 Big Data Analytics

The term 'big data' refers to data that is large and consists of a variety of different data. The increasing trend of digitalisation results in more companies having to deal with big data. Specifically, the volume, variety, and velocity of 'big data' distinguish it from non-big data. The volume refers to the amount of data. The combination relates to the different types and formats of the data. Velocity is the speed at which data changes or is generated (Nguyen et al., 2018). Elgendy and Elragal (2014) add two more "V's": veracity and value. Veracity concerns the reliability of the data based on the source. The value dimension is the information hidden within the data. Thus, new methods are needed as traditional data cannot adequately extract information.

Big data analysis can be divided into different sections for the context of this chapter. The following section describes various techniques found in big data analytics. The first subcategory is **Extract transform and load**. This technique needs its category as it is a preparation step for other BDA techniques. Big data can be loaded after storing it by an 'extract transform and load' method (ETL). Data is first extracted from the source. After which it is transformed, this consists of changing data formatting and removing unusable/unneeded data. Data is loaded subsequently. This method can lower the amount of data that needs to be loaded and allow for a more effective data loading (Elgendy & Elragal, 2014).

Techniques within the **Prescriptive analytics** category estimate the best possible action to achieve a specific goal. Optimalisation is the most published prescriptive analytic technique. Digitalisation in production has allowed for the use of it in manufacturing in the form of real-time optimisation. It is (currently) less used within logistics and supply chain (Nguyen et al., 2018) (Elgendy & Elragal, 2014).

Techniques within **predictive analytics** are used to estimate the most probable outcome. It can be separated into three categories: semantic analysis, forecasting and classification. Semantic analysis is applied only in demand management, while forecasting is used in more areas within SCM. Companies can better anticipate demand by analysing big data to predict upcoming demand and act accordingly. Supply chains can thus be managed more effectively.

The last technique is classification, which assigns classes to data based on data characteristics. Which is used in almost all areas (Nguyen et al., 2018) (Elgendy & Elragal, 2014).

Techniques derived from **descriptive analytics** are used to identify patterns and relationships within data and between variables. Within descriptive analytics, there are two techniques. The following methods are discussed: association, Advanced data visualisation (ADV) and performance measuring. Association refers to the method by which correlations within big data sets are identified. It is the most common technique from BDA (Nguyen et al., 2018). It can be applied in various business operations because of its generality. ADV is a technique designed to visualise large amounts of data.

Millions of data points can be visualised by using ADV. It can also visualise a variety of data types. By combining human reasoning with ADV, a method to analyse big data is achieved. This is done by visualising large amounts of data and allowing a human to view the data and pickup patterns (Elgendy & Elragal, 2014). It is the least published topic for BDA within SCM (Nguyen et al., 2018). Another technique is 'Performance measuring' of departments and business operations. Finding and monitoring performance indicators hidden within big data can allow for better decision-making. While not precisely an approach for PM/SCM, it would be applicable due to its generality (Elgendy & Elragal, 2014).

7.2.3 Examples of the applications

Examples can encourage to act but can inspire just as well. The following section describes six cases in which AI or ML is industrially implemented. Each example poses a specific focus and result, effectively simulating a broad perspective on the possibilities of incorporating AI or ML.

Demand planning: As mentioned in the previous section, forecasting and semantic analysis are established uses of machine learning in SCM. A practical example is: *"demand planning"* by Kinaxis. To quote Kinaxis on their demand planning, it uses inputs from: *"stakeholders, like sales, marketing and finance – and even customers and suppliers"*. They offer this as one of their solutions to their customers. Traditional forecasting is mainly based on sales data to forecast upcoming demand, with search volume indicating potential demand (Mitrea, Lee, & Wu, 2009) (Wu & Brynjolfsson, 2015). One can only imagine what is possible when many more variables are included in forecasting. With the rise of AI, it is finally possible to take advantage of the digitisation. AI offers greater accuracy because of its ability to process much more information effectively than traditional forecasting methods (Kinaxis, 2023).

Spend Management Technology: Another predictive analytic method is the example of *"Spend Management Technology"* by Simfoni. They have implemented machine learning to speed up the classification process of reports. Classification based on their characteristics is needed to group categorial expenditures. The data is visualised in an overview of all expenditures. If the data is extensive, a form of ADV is probably used, but this is not explicitly stated. This enables companies to get a proper understanding of their expenditures. If this is not done, a company cannot understand the make-up of their expenditures. Having a good overview will allow management to act quicker on disruptions regarding their spending. Having this done by an AI-enabled system allows for quicker automated outlines being generated in contrast to doing this manually or by a non-machine learning algorithm (Simfoni, 2023b).

AI-powered pricing: A form of predictive analytics is 'AI-powered pricing'. Accenture has developed it for Banca-Sella. Accenture combines "*market signals, competitive intelligence, and changes in customer preferences and buying propensities.*" (Accenture, 2023a) to obtain a dynamic optimal price. Having this done by AI enables companies to make an offer which is most effective based on the current situation. Since market disruptions are at an all-high time, it is necessary to quickly change prices or lose the competitive advantage (Accenture, 2023a).

Intelligent Care: A predictive analytic technique that is similar to demand planning. The example is from Accenture, which applied "Intelligent Care" for Vodafone UK. It does not only forecast the expected demand from customers. It predicts the type of demand the customer will have and acts accordingly. Customers facing technical difficulties of whatever kind are indicated by the tool and preventively send them messages. When customers get in touch with Vodafone, the system assigns them to a specific customer service section, thus saving time and improving the customer service experience. Customer satisfaction is improved, Vodaphone's efficiency increases, and the number of incoming customer calls has decreased in contrast to not having an AI-powered system (Accenture, 2023b).

Intelligent Revenue and Supply Chain Management System: another forecasting-related tool developed by Accenture when they partnered with Amazon is Intelligent Revenue and Supply Chain (IRAS). The IRAS system not only forecasts upcoming demand based on the real-time data it is given, but it can also recognise deviations in data patterns and predict disruptions. It does not stop here; it can also recommend actions to prevent bottlenecks in SCs. The considerable time saved by automation of the forecasting process, the analysis ability and the generated solutions are significant advantages of this AI and data-powered system (Tsukamoto, Park, & Sonti, 2020).

AI-powered sensors: Ensuring products arrive at their destination is key within every SC from a customer and supplier perspective. "*Sensors powered by AI"* can help detect deviation from a planned route by location tracking. They are also able to detect quality infringing damage. This applies to goods that must be kept at a specific temperature and humidity. AI sensors would allow timely alerts before goods are permanently damaged and allow SC managers to follow supplies when transported. This can be applied during transport and warehousing (Khazin, 2023) (Fletcher, 2023). An example of a system that works with this sensor type is *"GRAIN*" from EPAM. The system processes data from multiple sensors, "*such as a colour camera, thermal and depth camera, or those that measure temperature and humidity".* The system then uses ML and AI to analyse the data. This allows companies to collect large amounts of data and effectively process them for whatever goal (epam, 2023).

7.2.4 Benefits of AI and BDA

The previous two paragraphs discussed AI and BDA technologies, and advantages were mentioned or hinted at. In this paragraph, a summary of all the potential benefits of using AI and BDA is found. Regarding improving customer service experience, AI can help companies offer their customers more competitive prices based on the current state of an industry by applying AI-powered pricing. Customer experience can also be improved by automating a

customer's process to get a service/product by a system such as Intelligent Care (Accenture, 2023b) (Bray, 2023).

Cost reduction: when AI helps streamline internal processes, a company can reduce its waste (as in lean terminology) and offer a lower price than its competitors. Thus giving them a market advantage or increasing profit margins (Bray, 2023). Improving decision-making: AI is better at effectively processing large amounts of data. AI can be used to suggest optimal decisions (e.g. AI-powered pricing) or visualise large amounts of data (ADV) (Bray, 2023). Saving time by automating tasks is a significant benefit. If AI can be trained with a tremendous amount of data, it is possible to automate many jobs that had previously had to be done by employees. Automating these tasks allows employees to spend time on more human input-required tasks. An example of this is Intelligent Care.

Recognising new opportunities like demand planning, ADV, and AI-powered sensors are all examples of techniques that allow for opportunities to be recognised earlier due to AI's data processing ability. These opportunities cannot be quantified in cost or time but will undoubtedly improve business operations. Opposite to the opportunities identified by predictive techniques, risks can also be specified, assisting in Risk mitigation. AI may recognise a pattern indicative of a disruptive phenomenon humans may have overlooked, thus enabling better risk management (Bray, 2023).

AI-powered sensors can continuously and intelligently update operation parameters such that any unsafe conditions are discovered earlier or even predicted. Therefore, safety is improved by alerting management and workers earlier to hazardous conditions. Improving data quality can be challenging as ML systems must be trained with proper data. BDA techniques can also enhance it, where data is processed into usable data. The transform step in ETL methods is used for this purpose (S. Srivastava, 2023) (Simfoni, 2023a).

7.2.5 Implementation criteria

Until now, the developments and contents of AI and BDA techniques provide examples of applied methods and named benefits of using them have been discussed. However, there are requirements for AI to be effectively applied in practice. AI might not (yet) be a valid addition to a business operation. In this section, the criteria/factors of importance will be explored.

Data quantity and quality: ML systems are trained on data and require input to process into output, so data must be available in a 'proper' form. Suppose no data or too few data is currently collected within a company or a particular business operation. The required amount of data depends on the complexity of the technique that is being applied. Other factors are data quality, required accuracy and supervising level (Simfoni, 2023a). There are various estimation methods for the quantity of data needed. For example, a general rule is to have ten times as many data rows as you have features (Smolic, 2022). If required, BDA can improve data quality by applying ETL (Smolic, 2022).

Computing capacity: For ML, lots of large data sets are required. A specific processing capacity is needed for many computations (Witkowski, 2019). An example of improving the capacity is by buying better GPUs (Graphic Processing Units), as traditional CPUs (Central Processing Units) are slower than ML (Clayton, 2022).

Storage capacity: Data needs to be stored to keep giving AI more input so it can be trained. For actual-time decision-making, this data must be quickly accessible as continuously new data is needed, whereas accessibility is less critical for non-real-time systems. Non-real-time systems require more data to be stored (Witkowski, 2019).

Networking infrastructure: As AI requires constant input, the networking infrastructure must facilitate these data transfers (Kerravala, 2018). As business operations expand or the capability of AI techniques is explored, the digital infrastructure should be able to be scaled (Witkowski, 2019).

Security: AI may receive sensitive data as input, which must be processed so that no privacy and regulations are violated (Kerravala, 2018).

Training: Staff must be trained in working with AI to bridge the gaps from the current business operation to the new AI-integrated process (S. Srivastava, 2023) (Witkowski, 2019)

7.2.6. Implementation steps

Having established all crucial factors for implementing AI, it is necessary to explore the implementation roadway.

Identify areas fit for AI integration: It is best to start with small, simple processes before changing more extensive scale operations or designing new strategies with AI from the start (Bray, 2023). Suppose significant processes are automated at once. It can result in a disordered mess (Simfoni, 2023a). As employees must adjust to working with AI systems, it is also essential to take it slow so that they gain experience and trust in the system.

Market research: After establishing that numerous different BDA and AI techniques differ. Selecting a solution/technology that is the best fit for the operation is vital. Multiple providers might offer similar solutions with only minor differences. Market research will allow for the best solution to be selected and a good understanding of all possibilities. Selection criteria for a provider are (but are not limited to) experience with the industry of said company, customisation level, data security measures and cost (Bray, 2023).

Scoping: Before starting the implementation of AI models within business operations, the goal/purpose of the model must be established. The development of AI and subsequently operating the system can only succeed when its boundaries are set. With scoping, it is essential to give AI the most complicated processes for purchasing. An example would be the negotiation. AI is not suitable for automating these human-to-human interactions. For processes to be integrated with AI, it is essential to leave room for human input (Simfoni, 2023a). AI is not at the point where human information becomes obsolete, so it is best to designate and design your processes with this in mind.

Stakeholder input: The value created by the AI model must be based on the information of all stakeholders (S. Brown, 2021). This will enable the system to be of as much value as possible, and all stakeholders can benefit from the change.

Training data extraction: Data quality is an essential factor in AI models (as stated before), but in the beginning stage of training an AI model, quantity is preferred over quality (Simfoni, 2023a). Providing the model with as much information as possible will allow it to be trained

better and faster. If data is of such bad quality that it is unusable, it is necessary to explore data cleaning and pre-processing techniques (Bray, 2023).

Pilot testing: AI can be used to model processes found in reality, but before entirely depending on the AI models, the output must be tested (Bray, 2023). This can be done by periodically (during implementation) comparing the AI outputs with reality (Fletcher, 2023). It can also test the human input and AI system interface.

7.3 Conclusion

AI and ML demonstrated enormous potential in broad applications. Several different techniques and applications are covered in this research. Furthermore, the applications, benefits, criteria, and implementation steps are concluded as the following. AI, ML and BDA applications can be separated into six divisions: Demand planning, Spend Management Technology, AI-powered pricing, Intelligent Care, AI-powered sensors, Intelligent Revenue and Supply Chain management system. Each application brings its benefit. The benefits can be summarised into the following: improving customer service experience, cost reduction, improved decision making, saving time by automating tasks, recognising new opportunities, risk mitigation, improvement in safety, and Improving data quality.

The corresponding implementation criteria vary by each specific situation. However, the following are helpful to consider. There are various estimation methods for the quantity of data required. For example, the general rule is to have ten times as many data rows as you have features. In terms of computing capacity, lots of large data sets are required for ML. A certain level of processing capacity is needed for many computations. An example of improving the ability is buying better GPUs instead of relying on only CPUs. Data needs to be stored to keep giving AI more input so it can be trained. For actual decision-making, this data must be quickly accessible as new data is continuously needed. Therefore, data storage is a feasible investment for the efficiency of AI. Networking infrastructure is required to withstand heavy data transfer. AI requires constant input facilitated by the networking infrastructure. Security improvements may be necessary in some situations as AI may receive sensitive data as input, which must be processed so that no privacy and regulations are violated. Additionally, staff must be trained in working with AI to bridge the gaps from the current business operation to the new AI-integrated process.

The steps of integrating AI consist of the following steps. Firstly, identify areas fit for AI integration, start with small, simple processes before changing more significant scale operations or designing new processes with AI from the start. Selecting a solution/technology that is the best fit for your operation. Multiple providers might offer similar solutions with only minor differences. Market research will allow for the best solution to be selected and a good understanding of all possibilities. Thirdly, Scoping is essential to identify the goal and purpose of the model. The development of AI and subsequently operating the system can only succeed when its boundaries are established. The fourth step is to take stakeholder input into account. The value created by the AI model is based on the information of all stakeholders. The fifth step is training data extraction. When preparing an AI model begins, quantity is preferred over

quality. Pilot testing is the last step. AI can be used to model processes found, but the output must be tested before entirely depending on the AI models. The model can be scaled accordingly in case of successful tests. The framework is visualised in Figure 8 below.

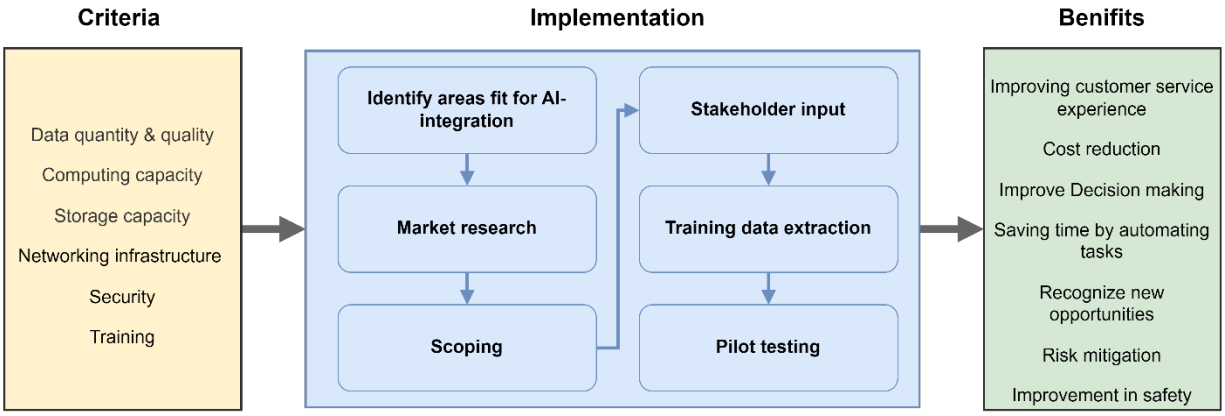

Figure 8, AI implementation framework.

Chapter 8 - Reshoring in the Supply Chain - Challenges and Drivers

Nick van Lambalgen, Twan de Roode and Stef Kosters

Abstract

The reliability of the supply chain has changed in the past years. Global issues had a direct impact on the supply chain. COVID-19 and the Suez Canal blocking have changed companies' decisions about offshoring and making reshoring an attractive option. However, some complications in the form of cost, capacity and intellectual property make reshoring complicated. Although there are complications in the supply chain when considering reshoring, there are also reshoring benefits that can outweigh these complications and strengthen the supply chain.

8.1. Introduction

Before 2020, companies that moved their supply chain offshore had a competitive advantage over competing companies that did not. Companies that offshored their supply chain paid less for production since the cost of workers and materials is lower in Asia (Alison Ashby, 2016; Goel, Moussavi, & Srivatsan, 2008). However, risks are associated with an offshore supply chain (S. S. S. Chopra, 2004). Offshore supply chains are long and susceptible to disruptions (Harrison, Skipworth, van Hoek, & Aitken, 2019).

In 2020, the growing impact of COVID-19 disrupted the entire supply chain (van Hoek, 2020). In 2021, the global supply chain got another disruption caused by one of the most crucial shipping routes, the Suez Canal, being blocked by a container ship. Disruptive events like COVID-19 and the Suez Canal blockage resulted in significant delays and supply chain interruptions, ultimately leading to substantial losses for companies with an offshore supply chain (Barbieri et al., 2020; J. M.-y. Lee & Wong, 2021).

As a result of disruption in the supply chain, companies are now developing new strategies to manage these risks (van Hoek & Dobrzykowski, 2021). Since COVID-19 and the blockade in the Suez Canal, companies have become more aware of the supply chain risks associated with production overseas (van Hoek & Dobrzykowski, 2021). As a result, companies are investigating shifting their manufacturing process back to their continent.

The complications of reshoring mentioned by van Hoek and Dobrzykowski (2021) are cost, capacity and intellectual property. Multiple types of costs are impacted by reshoring part of the supply chain. Necessary impacted prices include transportation costs, labour costs and inventory costs. Building the infrastructure is essential and can be divided into fixed and variable costs, which affect the total cost of reshoring. Lastly, production and material costs are also affected by reshoring. Materials can be more expensive in Western countries than in many Asian countries (Alison Ashby, 2016). However, material and production costs depend on many factors. In the text of the chapter below, no attention will be paid to highlighted types

of costs as they are out of scope. The following research question is formulated to understand what cost elements affect reshoring in the supply chain.

- RQ 1: What cost components are most affected by reshoring in the supply chain, and how can the costs be compared to offshore operations?

The second complication category after cost is capacity. If a factory is currently located in Asia, it has a working process. An offshore factory can operate efficiently with the workers in China. The workers in China know the process and have the expertise to manufacture the product. Moreover, the factory is already there with a specific capacity. Moving the manufacturing process to Europe is complex and would require a significant investment to get the same capacity as in Asia (McIvor & Bals, 2021). Another component of capacity is the employees. The employees in Asia are skilled enough to do their work correctly. The European workers need training to achieve the same level of skill as the workers in Asia. Moreover, new employees should be sourced in Europe, meaning it requires time and effort to reach the same level of skills again. The following research question is formulated to give an idea of how production and distribution capacity are influenced by reshoring.

- RQ 2: How does reshoring in the supply chain influence a company's production and distribution capacity?

The third complication is about intellectual properties (IPs) and the management of IPs. “Do the Chinese have different views?” is a paper from Lai and Zaichkowsky (1999) about brand imitation in China. In this paper by Lai and Zaichkowsky (1999), the different views on brand imitation and copyright infringement in parts of Asia have been discussed. Moving the supply chain to a different continent with other views on copyright and trade secrets complicates the protection of IPs. Protecting and securing IPs and co-developed IPs is complex but necessary for a functioning supply chain. The following research question has been formulated to research the impact of reshoring on intellectual property.

- RQ 3: How does the reshoring decision affect intellectual property management within the supply chain, and what methods can be used to protect or acquire intellectual properties?

8.2. Reshoring

For the last few decades, companies in developed countries have been focusing on outsourcing their manufacturing to low-labour cost countries so the companies could decrease the manufacturing costs of their products. The process of outsourcing manufacturing is named offshoring. As early as 1966, the importance of moving manufacturing to low-labour-cost countries to the global economy was discussed by Stopford and Wells (Davis, Ein-Dor, R King, & Torkzadeh, 2006). Companies globally mainly focused on offshoring until COVID-19 and the Suez Canal blockade devastated and halted the global supply chain (Guan et al., 2020; J. M.-y. Lee & Wong, 2021). As a reaction to these disruptions, companies are looking for ways to return their supply chain to their home country. According to Zhai, Sun, and Zhang (2016), reshoring is “the process through which a transnational corporation relocates all or part of

valuable activities conducted abroad to the home country of the transnational corporation". This implies that a specific part of the supply chain will be moved closer to the original country where the company is located. According to Gray, Skowronski, Esenduran, and Johnny Rungtusanatham (2013), there are four different types of reshoring where a firm fulfils demand:

- The first type of reshoring is "in-house reshoring". In-house reshoring is relocating the whole-owned production process from an offshore country to a new wholly-owned manufacturing process in the company's home continent.
- The second type of reshoring is "reshoring for outsourcing". Reshoring for outsourcing is relocating the wholly owned production process from an offshore country to a supplier in the company's home continent.
- The third type of reshoring is "reshoring for insourcing". Reshoring for insourcing is relocating the production process being performed by an offshore supplier back to a new wholly-owned manufacturing process in the company's home continent.
- The fourth type of reshoring is "outsourced reshoring". Outsourced reshoring is relocating the production process being performed by an offshore supplier back to a supplier in the company's home continent.

All the mentioned types of reshoring are focused on shortening the supply chain by finding onshore supplies or reshoring manufacturing.

8.2.1. Why is reshoring becoming more popular?

Demand for reshoring increased due to multiple significant global events that disrupted the supply chain. The first big trigger event that made offshoring less popular was COVID-19 (Boffelli & Johansson, 2020). During COVID-19, supply chains worldwide were disrupted for almost three years. The effects that COVID-19 had on the supply chain made it difficult for companies to obtain their products, especially when those are made in a foreign country. Preceding COVID-19, the container vessel *Evergreen* blocked the Suez Canal in Egypt for eight days. The Suez Canal sailing route is one of the busiest and most essential pass-throughs of the global supply chain, which was halted and blocked by the containership Evergreen (J. M.-y. Lee & Wong, 2021). As a result of significant disruptive events, companies gained firsthand experience in understanding the risks associated with extended supply chains. The longer a supply chain becomes, the harder it is to oversee it and the more it becomes susceptible to disruptions (Pettit, Croxton, & Fiksel, 2019). Multiple companies try to shorten their supply chain by reshoring their manufacturing to decrease the risks of disruptions.

8.2.2. Drivers of reshoring

Recently, companies have been looking to reshore their manufacturing process to decrease the supply chain length. By reducing the length of the supply chain, the risks on the supply chain for global disasters will be reduced (Pettit et al., 2019). Besides these risks, there are more advantages to reshoring. According to McIvor and Bals (2021), the following subjects could encourage companies to reshore their manufacturing.

Risk management and dependability: Companies want to reduce supply chain interruption risk by shortening their supply chain. Besides risk mitigation, there are additional benefits to

reshoring: supply chain risks, environmental issues, political issues, Intellectual Property protection, and delivery certainty as lead times decrease.

Costs: Different types of costs are affected by reshoring. Namely, transportation costs, labour costs and inventory costs. These costs will be explained in chapter 8.3.

Quality and brand image: It is much easier to control the quality of products when the manufacturing location is closer to the market. Furthermore, the brand image could be improved as it is made from home. An example is knives made in Switzerland (Park, MacInnis, & Priester, 2007).

Technology and innovations: When more companies are closer to home countries, technological clusters arise where more innovations are thought of, which can also be easily implemented.

Institution: Lastly, it is also essential that the home country can replace the offshore country. The home country should have enough skilled workforce, availability of resources, and availability of infrastructure.

8.2.3. Implementation consideration

Before reshoring, a company must deliberate what implementation considerations there are. According to Benstead, Stevenson, and Hendry (2017), there are two main categories which explain the implementation considerations, including "Location, ownership and timing" and "Operations and supply chain development".

Location, ownership, and timing

For a company to successfully reshore, the board of directors must be informed about the implementation and the goal of reshoring. Below are five critical factors that should be considered (Benstead et al., 2017).

Entry and exit modes onshore and offshore.

The relocation process of leaving the offshore nation and entering the domestic location must be understood. The better the process is understood, the smaller the change mistakes that will be made during the onshore process.

Maintaining production in a domestic location

A company needs to maintain a stable amount of output products to produce revenue. Whenever a company moves its manufacturing, it must be sure it can keep the flow of outputs produced in the new manufacturing. Therefore, the production process must be understood when reshoring the manufacturing to avoid problems.

Degree of reshoring

The company must decide what part of the production it wants to reshore. They should decide whether all the manufacturing should be reshored or just fractions of the company.

The tipping point of relocation

The timing of triggering the process is important. In other words, the company should start the reshoring process when it is ready, as it is long and expensive.

Process of implementation
Lastly, reshoring within the context of prior and future location decisions is essential and must be understood.

Operations and supply chain development

The second category focuses on what the company should do to improve the reshoring process. The remaining five factors are displayed below. (Benstead et al., 2017)

In-house training
The company should be able to train employees in their home country. By training employees, the company can ensure that the products can be produced at home.

Building solid relationships with suppliers, internal teams, and customers
The better the relationship between the stakeholders and the company, the more willing all parties are to help, and the easier it becomes to reshore.

Improving information sharing with suppliers, internal teams, and customers
The company should share the necessary information about reshoring with the right stakeholders—the more open, the fewer mistakes will be made.

Market movement
The company should follow the market movement and do what the stakeholders prefer. If there is much resistance, reshoring will be more challenging.

Global supply chain development
The company should develop and maintain a robust global supply network in such a way that it could be operational while shifting the manufacturing from offshore to onshore.

8.3. Cost

The main research question regarding the cost components is: What cost components are most affected by reshoring in the supply chain, and how are the cost components compared to offshore operations? As mentioned in section 8.1, there are three categories of costs affected by reshoring in the supply chain: transportation, labour, and inventory (and logistic) costs. This section will discuss and compare these different cost categories of reshoring with the costs of offshore operations.

8.3.1. Transportation costs

In the past, it was a trend for companies to offshore. Offshoring has several advantages, as mentioned in section 8.1. However, there are also several disadvantages to reshoring. One of the disadvantages is that the distance between producer and customer is longer for offshore companies than onshore companies. The gap is significant as the longer the distance a product travels, the higher the transportation costs (Calignano & Mercurio, 2023).

Besides the increase in transportation costs caused by longer travelling distances, the product also must be sent a month upfront, which means a long lead time. The longer the lead time,

the bigger the inventory costs. In section 8.3.3. , more information will be given about the lead time and inventory costs (Bailey & De Propris, 2014). After all, companies focus on offshoring as the advantages of offshoring outweigh the costs of a longer distance.

By reshoring, transportation costs decrease since distances become shorter. When bringing the operations closer to the market, the products must travel less distance. Travelling shorter distances establishes savings regarding transportation costs. Another non-cost-related advantage is that decreasing travel distances makes the transportation process less polluting (Alison Ashby, 2016). In recent years, transportation costs have risen significantly, meaning that reshoring also becomes more attractive. The reasons for the rise in transportation costs are increased energy costs and the rising interest in fast shipments, inventory costs and flexibility (Bailey & De Propris, 2014).

8.3.2. Labour costs

The second type of affected costs is labour costs. Labour costs include the expenses incurred by employers regarding employing workers.[1]

For many companies, an essential reason for offshoring is that in some parts of the world, labour costs are much lower than in the home country (Bailey & De Propris, 2014). China has been a famous offshoring country with relatively low wages (Goel et al., 2008). The average cost of a Chinese production manager is between 10 to 20 thousand dollars. In the United States, the average price of a production manager is above 70 thousand dollars (Institute, 2022). So, the same amount of work could be done for lower costs.

Moreover, working conditions were less critical to companies in the past than they are nowadays. If society notices that a company purchases goods from a location with lousy working conditions, it could significantly damage its brand reputation (Fratocchi & Di Stefano, 2019). Another disadvantage regarding labour, in addition to cost, is cultural and language differences between the company and the employees.

As mentioned in the previous section, the gap between labour costs in Western countries and (former) low-labour cost countries has decreased (Bailey & De Propris, 2014). So, offshoring caused by low labour costs becomes less usual. On top of that, the decreasing gap even led to an incentive for companies to reshore. The advantages of overseas production have decreased, while the disadvantages have increased. These disadvantages have been discussed in the previous section as well. Reputation can be damaged by acquiring products from lousy working conditions.

8.3.3. Inventory costs / Logistic costs

In Supply Chain Management, Inventory costs are an essential type of cost. In the past, companies neglected inventory costs. Nowadays, it is a crucial factor to consider. Logistic costs include inventory costs. Since inventory and logistic costs are closely related, these will be discussed in the same section.

[1] Definition of Labour costs by Insee (https://www.insee.fr/en/metadonnees/definition/c2219)

When companies decide to offshore, they know that the lead time will be much higher. The most common way to prevent stock-outs during lead time is to store safety stock. Having high safety stock leads to high inventory costs. In the past, costs regarding safety stock have been neglected by many companies. However, awareness of the charges has increased, and more companies are learning about their supply chain (Govindan, Azevedo, Carvalho, & Cruz-Machado, 2015). The economies of scale partially cancel out the high logistic and inventory costs since shipping happens in vast quantities.

When companies choose for reshoring, lead times decrease. Increasing lead times lead makes more extensive safety stock necessary, and in principle, inventory costs decrease[2]. Currently, logistic prices of operations in countries companies previously offshored have increased significantly in the past years. According to Ancarani and Di Mauro (2018), the rising costs of having suppliers in other continents are also an essential reason for reshoring. Another incentive for reshoring is that the market demands more variety than in the past. Because of variety, lead time should be short to respond fast to the market (Ancarani & Di Mauro, 2018).

8.4. Production & Capacity Utilization

There are complications and advantages to the reshoring of manufacturing and production output. The influence of reshoring on production is of interest as it indicates how much revenue a company will make. In the following subchapters, more information regarding the complications and advantages will be mentioned.

8.4.1. Production

The effect reshoring has on the production output depends on the type of company and the home country. In this paragraph, two types of factors within companies will be mentioned that impact a company's productivity. The first factor that impacts productivity is the amount of automatisation, and the second factor influences how sensible a company is for regulations.

Companies with repetitive processes that robots can replicate will benefit more from reshoring than companies that do not use robots in their production process (Krenz, Prettner, & Strul, 2021). An increased production can be achieved with more skilled employees in developed countries. However, the difference between the output of qualified employees and the employee from undeveloped countries is not big enough to bridge the cost gap. As mentioned in chapter 8.3.2, the benefit of low-cost labour in undeveloped countries is decreasing. The moment that robots can produce more efficiently than human employees, the cost and risks of reshoring are decreasing.

Whenever a company moves its manufacturing back to its home country, it is likely obligated to follow stricter regulations than manufacturing in an offshore country such as China. For example, China has softer safety regulations than the West (Chan & Nadvi, 2014). The effect of stricter rules on companies is that it reduces productivity and increases production costs (Dechezleprêtre & Sato, 2017). Notably, the more stringent environmental regulations harm

[2] In principle, inventory costs decrease by reshoring, but every case is different and other circumstances can affect this.

companies (Bals, Kirchoff, & Foerstl, 2016). Environmental regulations force companies to limit their emissions and impact on nature. The rules will most likely hurt a company's overall profit and production output.

8.4.2. Capacity utilisation

Capacity utilisation is an essential factor to consider when a company wants to reshore its manufacturing. According to Corrado and Mattey (1997), capacity utilisation is "a ratio of the actual level of output to the sustainable maximum level of output", meaning it is the efficiency of the output compared to the output of what a company could produce theoretically. When a company decides to reshore, its manufacturing and capacity utilisation will most likely increase, positively affecting the company. According to research by Bals et al. (2016), different companies experience positive growth in their utility capacity when reshoring their company.

8.5. Intellectual Property

The main research question regarding the IP components is: How does the reshoring decision affect intellectual property management within the supply chain, and what methods can be used to protect or acquire intellectual properties (IP)s?

Intellectual Property refers to creations of the mind used in commerce (WIPO, 2023). Alternatively, the exploitation rights in information (Drahos, 1999). There are different types of IPs in the supply chain. Important IPs in the supply chain are IPs on products, IPs for the processes to make these products and IPs of moulds to form certain parts needed to make products.

IPs are protected in law with patents, copyrights, or trademarks (WIPO, 2023). The supply chain changed from a vertically integrated supply chain to a globalised supply chain (S. S. S. Chopra, 2004). The suppliers are spread worldwide and are only sometimes owned by the companies that buy from the supplier (S. S. S. Chopra, 2004; Harrison et al., 2019). When the supply chain is globalised, risks associated with IPs increase (Faisal & Banwet, 2007). The European Union is a member of the World Intellectual Property Organisation (WIPO) and a signatory of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs). These agreements include Copyright, Trademark, geographical indications, industrial design, patents, layout designs of integrated circuits and undisclosed information (including trade secrets and test data) (Comission, 2023; Drahos, 1999). In other words, European companies producing their products in Europe are protected under European copyright law. When companies move their supply chain to another continent, there is a risk of stolen IP. S. S. S. Chopra (2004) stated two risk management strategies to mitigate the risks of stolen IP. The first risk management strategy is to bring or keep some production in-house. The second risk management strategy is maintaining a specific part of the business in-house, which can be quality control or necessary prototypes, which can mitigate the risk of stolen IPs.

There have been some recent developments in safeguarding IP by using the blockchain (Di Francesco Maesa & Mori, 2020). This method uses the blockchain on top of a "blockchain-supporting smart contract" (Di Francesco Maesa & Mori, 2020). A smart contract will prove that the data is accurate and define the operations allowed on such data. Smart contracts,

combined with the blockchain, are preferably applied in the music industry, where the artist is paid royalties. However, combining smart arrangements with the blockchain can also be used in the supply chain, as more computers are being used for production. In this application, the settings necessary for a process can be protected by this new blockchain technology, making it difficult to steal.

Protecting IPs is only sometimes necessary. In van Hoek and Dobrzykowski (2021), a co-development case is mentioned. In co-development, companies work together with the supplier to engineer technologies. Working with suppliers can earn the company a competitive advantage over the competition (Seuring & Müller, 2008). However, this competitive advantage only exists if the supply chain stays offshore. When the supplier is unwilling to sell its part of the IP or the IP is owned by the supplier, the technology must be re-engineered before the company can reshore. Not owning the IP can be a big hurdle for reshoring (van Hoek & Dobrzykowski, 2021). However, the advantage of reshoring is that the Research and Development (R&D) department is closer to the manufacturing site, making it easier to develop and implement new technologies.

When comparing the approaches to protecting the IP. One approach is keeping a part private Field (Chopra, 2004), while another is using the blockchain method (Di Francesco Maesa & Mori, 2020). Both methods achieve the same goal of managing IP and ensuring other parties cannot steal or use their IPs for their benefit without paying or asking permission. The difference between these methods is that the application of IPs has changed between 2004 and 2020. In 2004, most processes were still controlled by hand. In the current era, more systems are automated with preinstalled computer programs and inputs, meaning that managing IPs has different needs than in 2004. However, a collaboration of both methods can still be used to control and protect the IPs in the supply chain when a company wants to reshore.

8.6. Conclusion

Reshoring is “the process through which a transnational corporation relocates all or part of valuable activities conducted abroad to the home country of the transnational corporation” (Zhai et al., 2016). In the previous years, reshoring has become more popular for several reasons. The first reason is that reshoring reduces supply chain disruptions and uncertainty. The second reason is that the cost of production can decrease over time when the supply chain is reshored. The third reason is that it becomes easier to control the quality of products and improve the brand’s image. Lastly, it becomes easier to implement technologies and innovations. Since COVID-19 and the blockade in the Suez Canal, companies have become more aware of the supply chain risks associated with production overseas. Companies prefer to mitigate these risks, making reshoring an option to consider. Reshoring decreases the supply chain's length, decreasing the risk of disruption.

It is vital to consider the reshoring process's location, ownership, and timing when reshoring. In other words, it must consider the relocation process, the production's maintenance, and what part of the production to reshore. Moreover, it should start reshoring when it is ready to

do so and should consider past and future location decisions. On top of that, when reshoring, a company should take time and effort in operations and supply chain development in its home country.

Reshoring leads to a changing cost structure impacting almost all costs that have to do with the logistics. Three critically affected cost categories are transportation, labour, and inventory costs. When reshoring has been implemented, transportation and inventory costs will generally decrease. On the other hand, labour costs will increase because of the higher wages in Western countries.

Bringing manufacturing back to the home country most likely has both negative and positive effects on production output and a positive impact on capacity utilisation. Companies with many automatisations within their manufacturing will positively affect the production output as reshoring decreases lead time and more engineers are available in developed countries. Stricter regulations in developed countries harm the production output as it is more expensive and more complicated for the company to produce products. On the other hand, more stringent regulations will force companies to be more efficient with their resources, increasing capacity utilisation. Besides the regulations, a bigger pool of educated workforce positively affects capacity utilisation.

To make reshoring successful, the IP needs to be acquired and protected by repurchasing it from the original producer or re-engineering it with its capacity. The protection of intellectual property has become more complicated because of the advancement in technology.

In the upcoming years, an increasing number of companies will probably choose for reshoring since it is unlikely that supply chain disruptions will stop occurring. When companies consider reshoring, cost management, capacity, and intellectual properties are important factors to investigate.

Chapter 9 - Geopolitical influence on international supply chains

Stef Fisscher and Liz Greven

Summary

In the recent decade, multinational corporations thrived on free trade, but shifting global dynamics and economic challenges have brought concerns about trade friction. Various governments' actions are disrupting international trade and supply chains. This chapter examines how geopolitical influences affect global supply chains, highlighting the situation of the past decennium and the current drivers of change. The drivers are the Russian War, the U.S.-China trade war, EU policies and the influences of the BRICS countries. The chapter also discusses the importance of geopolitics in supply chain risk management, focusing on the relationship between politics, economics, and trade.

9.1 Introduction

9.1.1 Current situation of globalisation and free trade

In global trade, the flow of goods and services moving between countries has been helped by global connections and open trade. International trade between two or more countries generates economic motivation to remain peaceful with trade associates. This can be done by forming interdependent relationships (Daniels, Radebaugh, & Sullivan, 2019).

Global trade was emerging in the 1980s because of technological advancements in communication and transportation. This enabled organisations to buy and sell products from other countries worldwide. As a result, many multinational companies (MNCs) have shifted their production operations to Asia in the last decennium. These shifts in production have led to complex and global supply networks for industrial and consumer goods (Fan, Yeung, Tang, Lo, & Zhou, 2022).

Geopolitical influences have played an essential role in expanding international supply chains. Trade agreements have proven valuable instruments in stimulating economic growth in developing nations. After World War II, the United States was the driving force behind decreasing trade barriers such as tariffs and import/export restrictions. Free trade gained more and more support from governments and the corporate world, leading to the formation of the World Trade Organization (WTO) in 1995 and the finalisation of various regional and mutual trade agreements (Fan, Zhou, Yeung, Lo, & Tang, 2022).

The rise of globalisation in the past decades led to the current situation, where, due to geopolitical conflicts, international supply chains are changing. This leads to complications.

9.1.2 Complications for globalisation

Globalisation and open trade made much progress for many years until the emergence of challenges like the COVID-19 pandemic and geopolitical conflicts. These are geopolitical conflicts, such as the US-China trade war starting in 2018 and the Russia-Ukrainian war in 2022, which exposed the limitations of globalisation (Fan, Zhou, et al., 2022). In recent years, the idea of global trade is not separate anymore from the complicated world of politics between

countries. There are significant changes in how countries relate to each other, and it has become essential to understand how politics affect the movement of goods and services between countries.

The various geopolitical conflicts in recent times have led governments to put new restrictions on trade, making the world less connected (Witt, 2019). These conflicts have caused much uncertainty in how goods are produced, distributed, and delivered globally. As a result, organisations must rethink their global operational strategies (Fan, Yeung, et al., 2022). The geopolitical conflicts challenge the idea that the world used to be stable and open for business with few trade barriers.

9.1.3 Research question

On the topic of international supply chains and supply chain management, the literature is quite extensive. The situation contains multiple articles about globalisation and its elements, benefits, and disadvantages.

This chapter discusses the situation of the last decennium, the drivers of change and how these changes influence the international supply chains of organisations. Furthermore, how geopolitical factors should be incorporated into supply chain risk management strategies will be discussed. This chapter addresses the following research question: "How do geopolitical forces reshape international supply chains?" The research question will be answered through a scientific literature review.

9.2 Globalisation and free trade: open markets without trade barriers and tariffs

There have been various changes in the landscape of international relations in recent years, particularly concerning the principles of globalisation and free trade. For decades, globalisation was synonymous with expanding free trade and spreading interconnected economies (Daniels et al., 2019). Globalisation and free trade were essential in shaping international relations for much of the late 20th and early 21st centuries (Sally, 2006). The core principles of this era revolved around multiple elements, like open markets, trade agreements, supply chain integration, and economic interdependence.

The absence of trade barriers, tariffs, and restrictions between nations characterises the concept of open markets. This promoted the free flow of goods and services across the borders of various countries and continents. Governments increasingly viewed trade liberalisation to enhance economic growth and prosperity, leading to (Pekarskiene, Laskiene, Saboniene, & Susniene, 2017).

Another element is the introduction of multilateral trade agreements between two or more countries. Multilateral trade agreements are international agreements that aim to facilitate trade by reducing barriers, such as tariffs and trade restrictions, among participating nations (Jung, 2021). Multilateral trade agreements such as the General Agreement on Tariffs and Trade (GATT) and later the World Trade Organisation (WTO) significantly facilitated global trade. These agreements aimed to establish standard rules and promote fair and equal trade practices among nations (Balistreri, Kaffine, & Yonezawa, 2019).

The integration of supply chains on a global scale has also been an aspect of globalisation. Globalisation led to the integration of supply chains on an unprecedented scale. Organisations from various sectors expanded their operations across borders (Zhang, Tian, Li, Jiang, & Yang,

2022). One of the primary drivers of supply chain integration in a global context is the goal of cost efficiency. Organisations seek to take advantage of lower production costs in different regions of the world (Kim & Schoenherr, 2018). Another driver of supply chain integration is access to diverse markets worldwide. International supply chains enable organisations to access various markets. By manufacturing products in different locations, organisations can increase their market share and mitigate risks associated with relying on a single market (H. Liu, Ke, Kee Wei, & Hua, 2013).

Another aspect of globalisation found in literature is economic interdependence. As countries became economically interdependent, the consequences of any disruption in global supply chains became clearer. Economic crises in one country can quickly spread to others. For instance, the 2008 financial crisis began in the United States and had worldwide effects for most countries (Simpson, 2010). During these times, governments recognised the need for cooperation and stability to ensure the smooth functioning of their global economy.

In recent years, the traditional norms of globalisation and free trade have been challenged by complicating factors. The next chapter will discuss these drivers of transformation and their influences on international supply chains.

9.3 Drivers of Transformation: The Russian War, Trade War, Evolving Policies and BRICS

Certain geopolitical events have reshaped the dynamics of nations and economies in global affairs. This chapter discusses the drivers of transformation that have influenced the international supply chains of organisations. One of these drivers is the Russia-Ukrainian war, a geopolitical conflict that started in 2022. The war has had significant effects on international trade. These effects influence the attacked regions of the war and the whole world. Because of geopolitical impacts like these, governments are reconsidering their policies and regulations. This chapter explores the effects of these drivers on international supply chains.

9.3.1 The Russian war: disruptions and realignment of global supply chains

The Russian war began in 2022 and had profound and far-reaching effects on international supply chains and free trade. This conflict primarily centred around Ukraine, caused disruptions, and forced supply chains to adapt in unusual ways.

One of the most immediate and noticeable disruptions was the disruption of energy supplies. Russia is a significant exporter of oil and natural gas, and its conflict with Ukraine has raised concerns about the stability of these energy flows. This uncertainty led to fluctuations in energy prices, affecting industries worldwide (Cui, Yue, Nghiem, & Duan, 2023). Many countries, worried about energy security, started diversifying their energy sources and investing in renewable energy alternatives (Umar, Riaz, & Yousaf, 2022). This shift towards energy diversification was an essential step in mitigating the vulnerability of international supply chains to geopolitical conflicts.

The sanctions imposed on Russia by Western countries significantly affected global supply chains. These sanctions targeted critical Russian industries, including finance, energy, and defence (Van Bergeijk, 2022). As a result, organisations with ties to Russian partners or investments had to adapt to the changing business landscape quickly. Many multinational corporations re-evaluated their supply chain strategies to minimise exposure to geopolitical

risks by diversifying their supplier base and sourcing materials from less politically volatile regions (Y. Chen, Jiang, Wang, & Wang, 2023).

Furthermore, the war highlighted the vulnerability of supply chains to geopolitical events. Organisations started to emphasise supply chain resilience and risk management (Bigerna, D'Errico, & Polinori, 2022). The concept of supply chain resilience involves building flexible, adaptable supply chains that can withstand unexpected disruptions. This shift towards resilience meant that organisations had to rethink their sourcing strategies and establish backup plans in case of disruptions (Hussain, Nazir, Rashid, & Sattar, 2023).

The effects of the Russian war on international free trade extend beyond disruptions in global supply chains. Protectionist tendencies have gained attention in several countries. Governments have taken measures to safeguard their domestic industries and reduce their vulnerability to external shocks (Cui et al., 2023). These measures have led to reassessing trade agreements and introducing trade barriers such as tariffs and quotas on certain imports. These actions aim to shield domestic producers from foreign competition and stimulate domestic production (Afontsev, 2020). Several notable trends have emerged with the reassessment of trade agreements:

- Renegotiation of trade agreements: some countries have initiated efforts to renegotiate existing trade agreements to address new concerns or rebalance terms. Renegotiation can involve revisiting provisions related to tariffs, market access, and dispute resolution mechanisms (Beshkar, 2016).
- Pursuit of new alliances: The Russian war has resulted in countries exploring alternative trading partners and collaborations. This includes diversifying trading relationships beyond traditional partners and seeking new economic partnerships to mitigate geopolitical risks within their supply chains (Breslin, Freedman, Huston, Marrero-Garcia, & Mossburg, 2023).
- Greater emphasis on regionalisation: regional trade agreements have gained attention as countries seek to stimulate more robust economic ties within their immediate geographic regions. This approach enhances regional stability and economic resilience (Jagtap et al., 2022).

The Russian war has left a mark on international supply chains, leading to disruptions that have forced organisations and countries to adapt in various ways. It has accentuated the need for supply chain resilience, diversified supplier bases, and enhanced risk management practices. Moreover, the political conflict has challenged the principles of international free trade, with nations re-evaluating their trade agreements and alliances.

9.3.2 The U.S.-China trade war: trade tensions and supply chain diversification

The U.S.-China trade war, which unfolded over the past decade, has been a defining feature of global trade dynamics. The conflict can be characterised by escalating tariffs, sanctions, and trade restrictions, which have different implications for international supply chains.

One of the causes of the U.S.-China Trade War is the trade imbalance between both countries. China consistently exports more goods to the U.S. than it imports. This trade deficit fuelled concerns in the United States about the loss of jobs and decreased domestic industries (T. Liu & Woo, 2018). Next, the trade deficit the United States accused China of engaging in unfair trade practices. These include subsidies to domestic industries and non-tariff barriers limiting foreign organisations' market access (Yukon Huang, 2019).

As a result of these causes, former president Donald Trump declared the U.S.-China Trade War (Fan, Zhou, et al., 2022). This conflict has various consequences for international supply chains. One of the most visible consequences of the trade war was the imposition of tariffs by both nations. The United States imposed tariffs on a wide range of Chinese imports, and China responded with the same punishing tariffs on American goods. These tariff escalations disrupted established supply chains and increased costs for organisations on both sides (Benguria, Choi, Swenson, & Xu, 2022).

Many organisations began diversifying their supply chains to mitigate the risks associated with the trade war (Fan, Yeung, et al., 2022). They sought alternative sourcing options in countries unaffected by tariffs, reducing their reliance on Chinese manufacturing. Shifting between suppliers and factories led to new manufacturing hubs in other regions of Asia (Yi Huang, Lin, Liu, & Tang, 2023). International supply chains have become highly interconnected and reliant on Chinese manufacturing. Organisations faced disruptions as a cause of the trade war. Supply chain managers and organisations had to navigate uncertainties surrounding tariffs and trade restrictions, leading to delays in procurement, production, and delivery of goods (Gereffi, Lim, & Lee, 2021).

Because of the U.S.-China trade war, many organisations needed to rethink their supply chain strategies and adopt diversification measures. There are various strategies that organisations have adopted:

- Sourcing from multiple countries: organisations began to source materials and components from various countries to reduce their dependence on any single source. Multiple sourcing aims to enhance supply chain resilience and minimise exposure to geopolitical risks (Zhaohui Zeng, 2000).
- Regionalisation of supply chains: some organisations explored regionalisation by establishing manufacturing facilities closer to their primary markets. This approach reduced lead times and transportation costs while enhancing supply chain flexibility (S. Chopra & Sodhi, 2014; Zhang et al., 2022).
- Supplier audits and risk assessments: organisations conducted supplier audits and risk assessments to identify vulnerabilities in their supply chains. This proactive approach allowed them to mitigate risks and develop contingency plans (L. Chen, Yao, & Zhu, 2020).

The U.S.-China trade war, driven partly by concerns over trade imbalances and unfair trade practices, has had various consequences for international supply chains. Tariffs, sanctions, and trade restrictions disrupted the established supply chains and led to diversification efforts by organisations seeking to mitigate risks and maintain operations. The trade war has changed the landscape of global trade. Therefore, supply chain adaptation and multiple sourcing have emerged as possible strategies to navigate the changing trade dynamics between the two largest economies in the world.

9.3.3 EU Policy, GATT, and Supply Chain Due Diligence: Regulatory Challenges

The European Union has a significant influence on global trade dynamics. Its policies impact corporate behaviour, especially in supply chain management. One of the most critical aspects of the EU policy is sustainability and responsible purchasing (Fligstein & Merand, 2002). The European Union has introduced rules to ensure that organisations within its jurisdiction adhere to environmental, social and governance (ESG) standards (Tettamanzi, Venturini, & Murgolo, 2022).

For organisations participating in international supply chains, compliance with EU policies poses challenges on many fronts. Extensive due diligence processes are required to ensure that every link in the supply chain meets established standards. Due diligence is a comprehensive and careful examination of a situation to gather all relevant facts and information before deciding. This includes a critical assessment of suppliers' activities and environmental impacts of production processes and an evaluation of social responsibility initiatives. Failure to comply with EU policies can lead to heavy fines and reputational damage, making compliance a top priority for organisations operating in the European market (Barman, 2018).

The General Agreement on Tariffs and Trade (GATT) was established in 1947 as an international treaty that regulated world trade. This ensured free trade between participating countries was promoted (Barman, 2018; Crowley, 2003). The GATT has three basic principles. These are the principles of non-discrimination, transparency and reciprocity (Barman, 2018; Crowley, 2003). This can be done by reducing or simplifying import duties. For example, in 1947, customs duties were reduced, and other trade barriers were addressed. The phenomenon of dumping was also combated. This is exporting products below the production price to capture the market. In addition, it ensures that the production and supply chain are under the environmental and labour standards set out in the agreements.

The GATT played an essential role in forming the World Trade Organization (WTO) in 1995, which took over regulatory functions. Where the GATT mainly dealt with trade in goods, the WTO also created new procedures for settling disputes. As the World Trade Organisation (n.d) self indicates: “The World Trade Organization (WTO) is the only global international organisation dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by most of the world’s trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business”. The WTO accords are extensive and intricate due to their legal scope, encompassing diverse activities. Yet, at their core, they rest on simple, foundational principles that underpin the international trade system (2023):

- Non-discrimination
- Opening trade
- Predictability and transparency
- Fair competition
- Support for less developed countries
- Protection of the environment
- Inclusion
- Partnerships
- Digital trade

New trade agreements and economic sanctions may affect market access and product compliance requirements, including regulatory changes. This evolving policy means that organisations must always keep their eyes and ears open. In addition, there is the possibility that logistics and production plans will be disrupted due to geopolitical events. Political instability or natural disasters in strategic locations require risk management strategies. A recent example of an event causing disruptions in the international supply chains is the coronavirus outbreak (Grzybowska & Tubis, 2022).

Other supply chain risk-spreading strategies are achieved by expanding suppliers, for example, by considering suppliers from another country or region. It is essential to do extensive research when selecting suppliers. It can give an organisation an advantage when geopolitical shifts occur (S. Y. Tang, Gurnani, & Gupta, 2014).

Furthermore, engaging with government agencies and industry organisations could provide meaningful feedback and lobbying during political instability (R. S. Brown, 2016). Today, it is critical that organisations are inventive and intelligent in their supply chain approaches, as current geopolitics makes the global business environment highly dynamic. The supply chain of organisations should be adapted to the dynamic environment.

9.3.4 BRICS Influence on Supply Chains: Emerging Dynamics and Alliances

BRICS nations refer to five countries. These are Brazil, Russia, India, China and South Africa. These countries currently have the fastest-growing economies in the world. Goldman Sachs, an American business bank, referred to the rise of these countries (except South Africa) and their position in the global economy in a 2001 report. By 2050, the BRICS nations combined would surpass today's traditional Western economies. The BRICS countries are characterised by 42% of the world's population, and they have 30% of the land area. By the end of 2023, the BRICS countries will have 18% of world trade, but it is predicted that by 2028, this could already be 33% (Barbancey, 2023).

The BRICS countries have jointly established the New Development Bank (NDB). This bank is intended to support infrastructure and development projects in the BRICS countries and other emerging economies (Bank, 2023). Financial transactions can be conducted in their currency. An advantage is that the dollar and euro are thus circumvented. As these countries develop, their economic policies, regulatory frameworks and trade practices significantly impact international supply chains. Due to these benefits, more than 40 countries have shown interest in becoming members of the BRICS nations. Fifteen of these are listed as potential new members (NOS, 2023). The BRICS is seen as the place where the most significant economic growth will take place. It is attractive for certain countries to be a member of the group. Several countries want less dependence on the West (Barbancey, 2023). Moreover, they want to get rid of reliance on the dollar. It promotes local currencies and is looking at launching its own (Hodge, 2023).

The BRICS provides a counterweight to the West. It also allows countries to cooperate with some major world powers and creates alternative markets to grow. The BRICS alliance has contributed to diversifying international supply chains, reducing overreliance on Western-dominated routes and sources.

China's leadership in the BRICS alliance could bring even more profound changes. This country is a hub for various international supply chains with strong manufacturing capabilities. This has led multinational organisations to seek low-cost, large-scale manufacturing opportunities in China. However, recent geopolitical developments such as the US-China trade war are causing organisations to reconsider their reliance on China for sourcing and look elsewhere (Zhaohui Zeng, 2000).

China has made great strides in economic and commercial development in the world market. China is increasingly developing as a global industrial hub where high-quality products are sold at low prices. However, as more businesspeople focus on China's progress, they must pay attention to critical other countries, for example, neighbouring India, which may deserve more

attention than it has received (Saran & Guo, 2005). India has experienced growth in its manufacturing sector, driven by its large population and skilled workforce. This has made the country an attractive destination for organisations looking to establish production bases, especially in industries like IT, pharmaceuticals, and automobiles. Additionally, due to the competitive advantages offered by India, more businesses globally are considering it as a viable option for diversifying their supply chains (Saran & Guo, 2005). These production shifts have created complex global supply networks (Fan, Yeung, et al., 2022).

Before the war with Ukraine, Russia had a robust emerging economy. While the West created sanctions against Russia, the BRICS countries have not. For instance, India and South Africa have not condemned Russia. China has been careful to criticise the grain deal. Despite Russia being at war, many countries still want to join the BRICS nations (Hodge, 2023). When Russian influences within the international supply chain and sanctions are active, it can cause problems within the supply chain of Western organisations.

South Africa was the last country of the five to join the BRICS nations. The African continent has excellent economic and geopolitical potential through South Africa, the gateway to the continent. This fact makes it attractive for organisations seeking entry into the African market because Africa's society has grown (Vadra, 2017). BRICS countries see opportunities to trade with the rest of Africa through South Africa's accession. This also presents opportunities for the West.

The BRICS countries also work with SAARC, SCO, and IBSA to strengthen their economies and deepen regional integration. These partnerships have similar goals as the BRICS nations (ISLAM, 2019). These initiatives include the NDB, which finances infrastructure projects and improves connectivity between member states. Implementing such projects is changing local dynamics and becoming noticeable in supply chain strategies. As a result, the supply chain strategies of organisations are becoming more international.

9.4 Geopolitical Considerations in Supply Chain Risk Management

Risk, as defined by Harland et al. (2003), encompasses the potential for danger, damage, loss, injury, or any other undesired consequence. ‘Supply risk’, on the other hand, according to (Hoffmann, Schiele, & Krabbendam, 2013), means "the change of undesired events associated with the inbound supply of goods and services which have a detrimental effect on the purchasing firm and prevent it from meeting customers’ demand within anticipated cost and time”. Supply chain risk management primarily addresses four phases: identification, assessment, management, and monitoring of risk (Hoffmann et al., 2013).

Risk identification is the recognition of uncertainties. Risk assessment evaluates the likelihoods and consequences of prospective risks. Risk management is the (non-)use of mitigation strategies to take, counteract, diminish, or eliminate risks. Risk management can be either proactive or reactive. Risk monitoring is monitoring possible changes in risk probabilities and consequences (Hoffmann et al., 2013).

According to Hoffmann et al. (2013), supply risk can be distinguished into several components. The distinction between environmental and supplier (relationship) risk can be made. Environmental risk deals with political and environmental incidents which a company cannot directly influence. An example of an ecological risk is a natural disaster. Supplier (relationship)

risks are situations where a company could have more influence. This type of risk can be further subdivided into 'financial-', 'operational-' and 'strategic risks'.

Figure 9.9 - Pyramid of risk (Hoffman et. al., 2020)

Success in supply chain risk management begins with a risk assessment. It involves monitoring global market trends, intercontinental political dynamics, business activities and international wars in line with their production sectors, for example, the tension in international trade between the US and China. Organisations should undertake simulations related to geopolitics as this will help them adequately prepare for any potential disruptions within their supply chain. Currently, often the only known suppliers are the 1st tier suppliers. This is the direct supplier of the focal firm. The 2nd tier, 3rd, and nth tier suppliers are not known. This can also cause problems. Suppose the 3rd tier supplier is from Russia. This could be a problem for the entire supply chain (Kappel, Schiele, & Buchholz, 2020).

Geopolitical risks can also be minimised using different suppliers spread across regions. In this way, organisations diversify their purchases across provinces to reduce the shocks from over-dependence in one country (Zhaohui Zeng, 2000).

9.5 Conclusion

This chapter aimed to discover how geopolitical forces are reshaping international supply chains. The literature review revealed several issues where geopolitical forces can indeed impact global supply chains. In the late 20th and early 21st centuries, supply chains were already affected by the growth of globalisation and free trade. Trade liberalisation and multilateral agreements, such as the first 'GATT' and later the 'WTO', boosted global trade in goods. Therefore, the increased economic interdependence highlights the importance of cooperation and stability for the sustainability of international supply chains in the presence of geopolitical forces.

The war between Russia and Ukraine exemplifies how geopolitical conflicts can directly affect international supply chains. Disruptions caused by the war have forced organisations to adjust their strategies. This has come partly because of the sanctions imposed on Russia by the West.

The political conflict has challenged the principles of international free trade, with nations re-evaluating their trade agreements and alliances. This forced supply chains to adapt in unusual ways. The war has highlighted the need for supply chain flexibility and risk management practices.

The US-China trade war has also changed global trade. Massive tariffs and trade restrictions have prompted organisations to rethink their reliance on Chinese production. Through diversification strategies, organisations have tried to mitigate risks and ensure continuity. One way to do it is through sourcing goods from multiple countries and regionalising supply chains.

BRICS countries exert a significant influence on international supply chains. Economic growth, infrastructure initiatives and cooperation efforts are changing global trade dynamics. This presents both challenges and opportunities for organisations worldwide. The BRICS countries provide a counterweight to the West. Establishing the New Development Bank is an excellent example of the emerging economy of the BRICS countries in world trade.

The literature has shown that geopolitical forces can reshape the international supply chain in several ways. This is and will always remain the case. Organisations can see this as an opportunity and as a threat. For example, the emerging economies of the BRICS countries have a significant growth potential for other countries seeking new markets. But certainly, the risks of geopolitical events could arise. Risks must be 'identified', 'assessed', 'managed' and 'monitored'. In this chapter, a distinction is made between different types of risk. The two main types are environmental- and supplier risks. Environmental risks can be challenging for organisations to present because of risks that may occur unexpectedly.

On the other hand, organisations can strategically reduce the influence of supplier risks. Supplier risks are risks that can be expected to occur. Reducing the influence can be done by diversification of the supplier base. Diversifying suppliers across different regions and levels of the supply chain provides a buffer against geopolitical shocks. Simulations and scenario planning can also help organisations prepare for potential disruptions. Visibility is limited primarily to 1^{st} tier suppliers. It is essential to have insights into the 2^{nd} to n^{th} tier suppliers to detect potential risks earlier. These strategies can prevent problems throughout the international supply chain.

Chapter 10 - Supply Chain Resilience in the Automotive Industry: Anticipating Disruptions and Natural Disasters

Renee Seuntiëns, Daan Pierik and Wolf Jansen

Summary

Companies in the automotive industry have developed complex global supply chains. This development made these supply chains especially prone to be disrupted. A disruption can originate from four sources of supply risk: environmental, financial, operative, and strategic. Supply chain disruptions have significant consequences. Therefore, automotive companies should improve the resilience of their supply chains. There are two measures to strengthen resilience: preventive and reactive. This chapter elaborates on preventative and reactive measures that companies in the automotive industry can implement to enhance the resilience of their global supply chains to the four sources of disruption risk.

10.1 Introduction

Until several decades ago, many companies in the automotive industry manufactured their products internally rather than purchasing them from suppliers. For example, the Ford Company made its glass instead of buying it from a glass manufacturer (Miles & Snow, 2007). During the early 20th century, the automotive supply chain was relatively simple, comprising only a few steps and processes, from initial production to the end user (Reddy, Gunasekaran, Kalpana, Sreedharan, & Kumar, 2021; Vahlne & Ivarsson, 2014)

In the 1990s, there was an increase in the amount of trade agreements (Anderson & Yotov, 2016) and the formation of the World Trade Organization (Subramanian & Wei, 2007). These events lowered trade barriers, thereby increasing the possibility of sourcing internationally. Furthermore, it is noteworthy that the internet, which became widely accessible during the same time, enhanced the process of globalisation (Ben-Daya, Hassini, & Bahroun, 2019). As a result of globalisation, companies could source from many suppliers worldwide and collaborate with suppliers that fit their goals and strategy best. Companies began outsourcing their non-core business activities. Ford Company, for example, outsourced the car window production (Miles & Snow, 2007). By doing so, global automotive supply chains could create a competitive advantage (Prasad & Sounderpandian, 2003).

Globalisation has resulted in automotive supply chains growing in length and complexity. In a typical automotive supply chain for the consumer market, the supply chain consists of an OEM (original equipment manufacturer), tier-1 component suppliers, tier-2 component suppliers, and tier-3 raw material suppliers (Reddy et al., 2021). The typical automotive supply chain is illustrated in Figure 1.

The growing length and complexity of the automotive supply chain make these supply chains more vulnerable, which makes supply chains more prone to be disrupted by economic, political, social, or natural disruptions (S. K. Sharma, Srivastava, Kumar, Jindal, & Gupta, 2023). Since partners in the supply network are connected and dependent on each other (Vahlne & Ivarsson, 2014), one disruption somewhere in the supply chain could ripple through the supply network and have significant consequences for supply chain partners located thousands of kilometres away. An illustration of a disruption in the automotive supply chain can be observed in the aftermath of the 2011 Japanese earthquake, which resulted in a tsunami and the Fukushima nuclear disaster. Following these events,

Japanese exports of vital automotive components experienced a significant drop, impacting global vehicle production. Companies like Toyota, Honda, Opel, Nissan, and General Motors halted production after the earthquake, incurring losses of US$139 billion (Arto, Andreoni, & Rueda Cantuche, 2015).

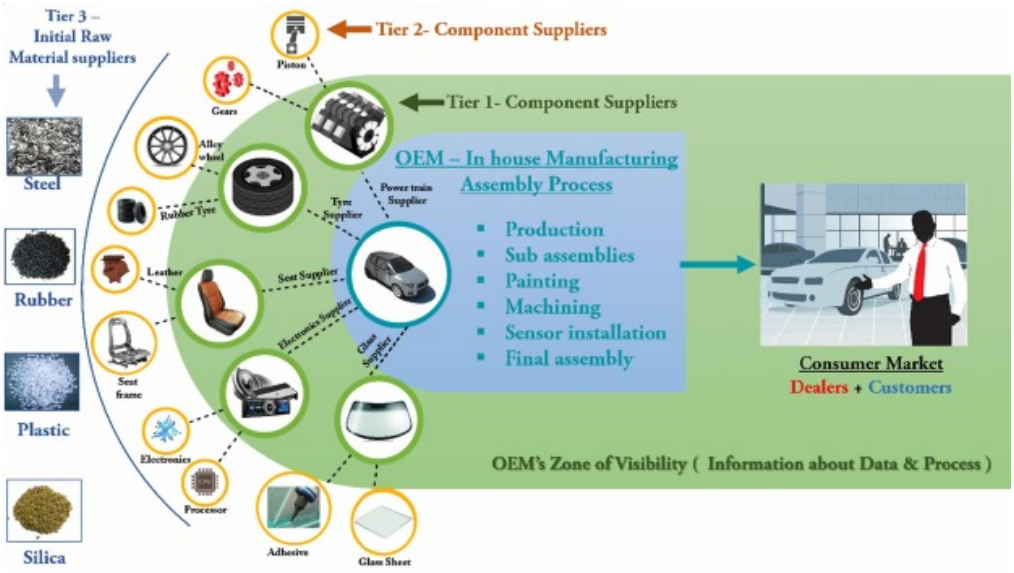

Figure 1. Typical automotive supply chain (Reddy et al., 2021)

Considering these significant consequences of supply chain disruptions, automotive companies must enhance the resilience of their global supply chain to mitigate such disruptions effectively. Therefore, the following research question is developed:

- ***How can firms in the automotive industry improve the resilience of their global supply chains to supply chain disruptions?***

The research question will be addressed through a sequence of sections. Firstly, the supply chain disruptions will be explored in section 10.2, followed by research about supply chain resilience in section 10.3. Section 10.4 concentrates on methods to enhance supply chain resilience to supply chain disruptions. Ultimately, the findings and conclusions will be presented in section 10.5. Section 10.6 consists of a discussion.

10.2 Supply Chain Disruptions

Supply chain disruptions can be defined as unintended, unforeseen incidents that breach the regular product flow of a supply network (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007). A supply chain disruption could prevent products from flowing through the supply chain (Scheibe & Blackhurst, 2018). It can significantly negatively impact the performance of companies in the supply chain (Blackhurst, Dunn, & Craighead, 2011). Nowadays, firms desire speed and efficiency from their globalising supply network, which increases the likelihood that disruptions ripple through the supply network (Scheibe & Blackhurst, 2018). In the automotive industry, supply chains are globalised, complex and focused on just-in-time production, making them especially prone to disruptions (Ambe & Badenhorst-Weiss, 2010; Thun & Hoenig, 2011).

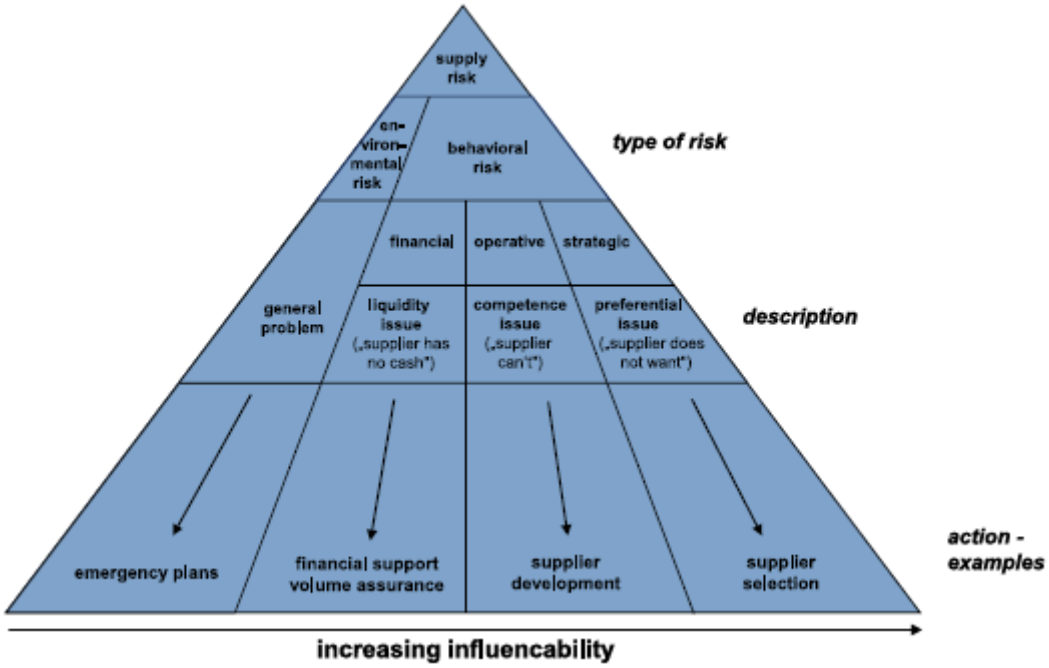

Figure 2. Supply Risk Model (Schiele et al., 2021)

Different types of supply chain risk could cause a supply chain disruption. Following the supply risk model created by Schiele, Hoffmann, and Koerber (2021), there are two types of supply chain risk: (1) Environmental risk and (2) Behavioural risk. Environmental risks include incidents that could happen in the ecosystem of a company's supply network, which could inhibit the ability of the company to deliver products to its customers (Schiele et al., 2021). An example of an environmental risk is the earthquake in Japan in 2011. Behavioural risks include incidents that could happen either at a supplier or in the collaboration between the supplier and the focal firm (Schiele et al., 2021). Behavioural risks can be further divided into three categories: (1) financial, (2) operational, and (3) strategic (Schiele et al., 2021).

The main difference between behavioural risk and environmental risk is that behavioural risk is more individual and firm-specific, whereas environmental risk influences many companies at once (Schiele et al., 2021). The complete supply risk model developed by Schiele et al. (2021) is illustrated in Figure 2. The figure reveals that firms have the least control over environmental risks and can increasingly influence risk when moving from financial to operative to strategic risks (Schiele et al., 2021). Below, each category of supply chain risk will be further explained, and an example of a supply chain disruption in the automotive industry caused by each supply chain risk will be elaborated upon.

Firstly, the Japanese 2011 earthquake is an example of an environmental risk. The Japanese earthquake in 2011 had significant consequences for the automotive industry. Not only Japanese automotive producers were impacted. Other impacted companies include the (non) Japanese suppliers of Japanese automotive producers, the suppliers of these suppliers, the customers of intermediate products produced by Japanese automotive manufacturers, and other suppliers of these customers (Arto et al., 2015). Hence, the earthquake's impact rippled through the supply networks of many companies in many countries. Combined, the production value of these Japanese and non-Japanese companies in the automotive industry declined by US$139 billion (Arto et al., 2015).

Secondly, there is financial risk. Financial risks include incidents where a supplier is no longer financially viable, such as supplier liquidation (Schiele et al., 2021). An example of a financial risk which could have caused a supply chain disruption in the automotive industry is the bankruptcy of Land Rover's chassis supplier. Land Rover only realised the supplier's bankruptcy when no supplies arrived. Without a solution, Land Rover would have to stop manufacturing the Discovery model for three quarters, and 11,500 employees at both Land Rover and its suppliers would be at risk. Land Rover ultimately struck a deal with an intermediary supplier (Sheffi & Rice Jr, 2005).

Thirdly, there is operative risk. Operative risks include incidents where a supplier cannot adhere to the specifications of the focal firm (Schiele et al., 2021). Carvalho, Naghshineh, Govindan, and Cruz-Machado (2022) discuss the impact of missing supplies on a Portuguese car manufacturer. Missing supplies not only means that the plant may need to temporarily stop production, increasing idle time of machinery and employees, but it also has consequences for the entire supply network (Carvalho et al., 2022). As the amount and type of cars manufactured change, other suppliers of the car manufacturer also have to adapt their manufacturing agenda to align with the new plan of the focal firm (Carvalho et al., 2022)

Lastly, there is strategic risk. Strategic risks include incidents where a supplier chooses not to adhere to the specifications of the focal firm, for example, when the supplier favours another customer over the focal firm (Schiele et al., 2021). An example of a strategic risk occurred during a chip shortage. Only 11% of chip production is bought by automotive companies (Mohammad, Elomri, & Kerbache, 2022). When a chip shortage occurs, automotive companies compete with each other and all other significant industries requiring chips. Chip manufacturers can provide a limited amount of chips to large customers instead of the relatively small car manufacturers. The chip shortage could reduce American car manufacturers' income by $61 billion (Mohammad et al., 2022).

10.3 Supply Chain Resilience

The core concept of resilience is related to the ability of a system to return to a stable state after disruption, which involves the ability to withstand systematic discontinuities and adapt to new risk environments (Starr, Newfrock, & Delurey, 2003). In a supply chain context, resilience is a firm's ability to recover from disruptive events and bounce back from a disruption (Sheffi & Rice Jr, 2005). Sheffi and Rice Jr (2005) suggest that building a resilient supply chain could be a strategic initiative because the flow of goods through a supply network is essential for the firm's existence. In the same way, Zsidisin*, Melnyk, and Ragatz (2005) mention that a firm's capability to survive after a disruption is directly related to the level of resilience in the supply chain.

The automotive industry is characterised by factors that make the supply chain especially prone to disruptions (Ambe & Badenhorst-Weiss, 2010; Thun & Hoenig, 2011). The supply chains of companies in the automotive industry are highly vulnerable to a turbulent external environment. This is because the industry is highly globalised and uses complex supply chains. Managing these risks and uncertainties is essential to survive disruptions, which can be considered supply chain resilience (Gebauer & Tangour, 2023). Furthermore, companies in the automotive industry further streamline their processes to beat the competition. Concepts such as just-in-time and just-in-sequence further align the supply chain (Svensson, 2004; Thun & Hoenig, 2011). Having a very lean supply chain, as is seen in the automobile industry, results in cost-effective, low inventories on the one hand, but on the other hand, leads to a highly vulnerable supply chain since turbulences cannot be compensated without safety stocks (Thun & Hoenig, 2011).

Thun and Hoenig (2011) elaborate on different types of instruments to cushion effects from disruptions and create resilience, differentiated between preventive and reactive instruments. Both instruments are actions conducted before disruptions happen, but their nature differs. Preventive instruments aim for risk avoidance, where the effect of the instrument is seen before a particular incident occurs. Furthermore, preventive instruments lower the chance of a specific disruption happening, thus creating more resilience by being more agile and flexible (Sheffi & Rice Jr, 2005; Thun & Hoenig, 2011). Reactive instruments can also generate resilience in the supply chain. Reactive instruments are induced before an incident happens, but the effectiveness will be known once the incident occurs. Instruments that are reactive strive for mitigation of adverse effects from disruptions. Reactive instruments are related to building resilience where redundancies are established, and robustness is created (Sheffi & Rice Jr, 2005; Thun & Hoenig, 2011).

The level of resilience can be quantified by assessing the current status of the performance of any system. Over time, performance can change, sometimes gradually, sometimes abruptly. Abrupt changes in performance occur in the case of disastrous events like a major earthquake. In these cases, the resilience of this system is tested (Sheffi & Rice Jr, 2005). Resources are then needed to restore a system's performance to its normal levels. Similarly, the performance of a system over time can be characterised as a path through the space of performance measures. The quantification of the level of resilience is the amount of time (t) the system needs to run at 100% capacity again (Dyckman, 2009).

10.4 How to Improve Supply Chain Resilience to Supply Chain Disruptions

10.4.1 Environmental Risk

Predicting environmental risks is challenging, and acting involves significant expenses that cannot be avoided because of the low influenceability. Nevertheless, preventive measures can be employed to mitigate them. One preventive instrument to address environmental risks is to use supply chain mapping. A supply chain mapping diagram shows the flow of materials from the upstream to the downstream supply chain (Reddy et al., 2021). Mapping helps evaluate the automotive supply chain, as it supports basic and advanced analyses for recognising potential environmental risks. Numerous components are involved in the automotive supply chain, resulting in a highly complex supply chain. Mapping the upstream and downstream supply chain for all parts is highly complex and resource-intensive. The mapping tool is typically applied to products within the automotive supply chain with a high-risk level, such as software (Kraljic, 1983; Norwood & Peel, 2021; Reddy et al., 2021).

By implementing supply chain mapping, automotive industry companies gain visibility into their components' origins. The information facilitates the identification of regions susceptible to vulnerabilities, such as those marked by political instability, climate-related events, or natural disasters. Section 10.3.1 mentioned an example of a natural disaster, the earthquake in Japan, which significantly impacted the automotive industry (Arto et al., 2015). As an illustration, Toyota ceased production due to significant disruptions in its raw materials and components supply caused by the earthquake (Ghadir, Vandchali, Fallah, & Tirkolaee, 2022).

The presence of natural disasters in the region can be attributed to its geological characteristics. In Japan, four major tectonic plates converge the Pacific Plate, Eurasian Plate, Philippine Sea Plate, and North American Plate (Maruyama, Isozaki, Kimura, & Terabayashi, 1997). These plates interact by sliding against each other, resulting in earthquakes. Being aware of the high earthquake risk, the automotive industry could choose to relocate from Japan and establish manufacturing facilities in safer locations.

Alternatively, companies can use a multi-sourcing approach to engage multiple suppliers to ensure the reliability of product delivery (Arto et al., 2015). Furthermore, using supply chain mapping, the automotive industry can identify the suppliers impacted by the earthquake and assess the resulting implications for their supply chain. Conducting thorough research could mitigate environmental risks, lowering the likelihood of automotive supply chain disruptions (Arto et al., 2015).

When examining the effects of natural disasters, such as the Japan earthquake, on the automotive industry (Arto et al., 2015), it becomes clear that their consequences are substantial. Given the potential for Japan to face more earthquakes, which could once again disrupt the automotive sector, implementing a responsive tool called scenario planning holds promise. Scenario planning offers an alternative approach for car manufacturers to formulate strategies distinct from conventional methods (Varum & Melo, 2010). Scenario planning proves valuable for making decisions in uncertain situations, especially during unexpected events like earthquakes. To formulate these strategies, car manufacturers must first identify the critical factors. Subsequently, the car manufacturers can create scenarios to assess potential favourable outcomes. Upon analysing these scenarios, a tailored strategy can be formulated (Varum & Melo, 2010). By identifying uncertainties, car manufacturers can create plans to avoid common decision-making errors, such as overconfidence or a narrow focus (Schoemaker, 1995).

When employing scenario planning strategies, it becomes crucial to balance the efficiency and resilience of the automotive supply chain by strategically integrating key capabilities (Gebauer & Tangour, 2023). For example, components utilised across multiple product lines should be supplied by various providers, supported by extra production capacity and storage alternatives. Scenario planning ensures the automotive industry is well-prepared to respond effectively during unforeseen events, such as earthquakes (Gebauer & Tangour, 2023).

10.4.2 Financial Risk

Financial risk is a behavioural risk that can occur within the buyer-supplier relationship. Financial risk can be described as alterations related to the possibility of a supplier's default, insolvency, or bankruptcy. Throughout the diversification phase of a crisis, the firm's cash flow and the supplier's financial situation should be kept in view (Schiele et al., 2021).

Although it's impossible to foresee financial risks with absolute certainty, preventive measures and tools can be employed to reduce and manage them. One of these preventative measures to combat financial risk in the automotive industry is to regularly analyse suppliers' financial health and stability through a supplier credit assessment. By doing so, a credit risk can be avoided. Credit risk arises from uncertainty in each counterparty’s ability to meet its obligations (Fatemi & Fooladi, 2006). By implementing supplier credit assessments, potential issues regarding suppliers’ financial health can be noticed early, and actions can be taken. The notable high-risk suppliers can be identified and considered. Land Rover, for example, only realised the bankruptcy of its supplier when no supplies arrived (Sheffi & Rice Jr, 2005). If Land Rover had implemented supplier credit assessments, they might have been able to realise the financial difficulties of the supplier earlier. Land Rover could have taken measures to help the supplier find alternative suppliers in time.

Furthermore, the company's creditworthiness is to be evaluated, which can affect the payment terms and contractual agreements in place. This is especially helpful when the customer has a second similar contract with another party. By doing so, the customer can often not meet the obligations of one of the two contracts. So, the actual risk of one deal depends on the other deals being made. This counterparty risk can be mitigated in the terms and contractual agreement (Scheibe & Blackhurst, 2018).

Transactions between different parties often involve some form of a monetary fee. To reduce non-payment risk, the supplier can purchase trade credit insurance. This ensures manufacturers, traders, and providers of services against the risk that their buyers will not pay or pay very late. This responsive measure reduces credit risk-related losses and creates more working capital for the firm. This position makes applying for financing from banks or other institutions less complicated, which can help the firm further innovate. Moreover, a catastrophic event like a health pandemic can occur, where the customer cannot meet payment terms or, in the worst case, go bankrupt. Approximately 80% of global trade involves trade financing approaches, and the market for trade finance has reached US$12 trillion annually (Qin, Qin, Cheng, & Wu, 2022).

Implementing trade credit insurance for both parties involved will mitigate non-payment risk. The insurance clausula will be activated once the payment cannot be fulfilled. However, this measure may be costly for both parties. Another way to look at the problem is to find a powerful firm in the supply chain that is willing to cooperate and finance other firms in their supply chain. More and more large buyers are embracing the supplier finance concept to stabilise the supply chain's financial health. Large buyers look to these programmes to provide their suppliers with working capital/liquidity and to lower the cost of financing when done by a third party. Large businesses have embraced this strategy with a supplier base tied to the automotive industry (Dyckman, 2009).

10.4.3 Operative Risk

Operative risks include incidents where a supplier cannot adhere to the specifications of the focal firm (Schiele et al., 2021). For example, the inability of a supplier to deliver the agreed quantity of products on time is an operative risk. The problem could occur because of a lack of components or because the supplier cannot produce the required supplies (Carvalho et al., 2022). Another example of an operative risk is that the supplier cannot deliver the right product quality.

If there are few suppliers for a particular product and the supply risk is high, then the supply type is on the right side of Kraljic's matrix (Kraljic, 1983). In this case, it is impossible to switch to another supplier if the firm's current supplier cannot deliver the necessary supplies. It is essential to have a strong relationship with key suppliers (Sheffi & Rice Jr, 2005). In the automotive industry, the effect of an operative risk can be diminished by regularly holding meetings with key suppliers to discuss possible supply chain disruptions. Again, a strong collaboration within the supply network is required (Carvalho et al., 2022). Collaborating and establishing the aforementioned strong relationship mitigates disruption risk (Ghadir et al., 2022) and reduces the negative effect (Carvalho et al., 2022). It is, therefore, both a preventive and reactive measure to enhance resilience.

Moreover, collaboration, combined with IT systems that support the sharing and alignment of information, enhances supply chain visibility (Carvalho et al., 2022). Supply chain visibility, in turn, entails that the focal firm is informed about its supplier's inventory levels and manufacturing plans and can, hence, mitigate operative risks (Ghadir et al., 2022). Therefore, supply chain visibility reduces operative risks and improves supply chain resilience (Carvalho et al., 2022; Ghadir et al., 2022). Enhancing supply chain visibility is a preventive measure to increase resilience, as it diminishes the causes of a supply chain disruption resulting from an operative risk.

If the operative risk is centred around the lack of quality of supplies rather than the quantity of supplies, then the focal firm could consider engaging in supplier development. The company should only consider engaging in supplier development for strategic supplies (Handfield, Krause, Scannell, & Monczka, 2006; M. J. Sharma & Yu, 2013). By engaging in supplier development, the focal company reduces the risk that the supplier delivers products of insufficient quality. It is, therefore, a preventive measure to enhance resilience.

One crucial side note, however, is that the critical supplier may not want to form a close relationship with the focal company, for example, if the focal company forms only a tiny part of the supplier's revenues. Then, the focal firm could decide to redesign its product. BMW redesigned its product to reduce reliance on chip suppliers (Mohammad et al., 2022). Redesigning a product is a reactive measure to enhance resilience since the redesign action minimises the effects if another chip shortage occurs, not the causes of the chip shortage.

If there are numerous suppliers for a particular product, then the supply type is on the left side of Kraljic's matrix (Kraljic, 1983). In this case, it is possible to switch to another supplier relatively quickly if the firm's current supplier cannot deliver the requested supplies. If the supplier cannot deliver the right quality, the focal company can consider switching suppliers rather than engaging in costly supplier development.

Furthermore, multiple sourcing is possible because there are numerous suitable suppliers for the supply type. Namdar, Li, Sawhney, and Pradhan (2018) discuss different strategies depending on the kind of disruption and the risk attitude of the firm. If the disruption risk includes disruptions that occur often but have a minor impact, the firm should use multiple sourcing independent of its attitude towards risk (Namdar et al., 2018). When doing so, the company should focus on diversification to enhance resilience (Namdar et al., 2018). Multiple sourcing is a reactive measure to strengthen resilience, as it minimises the effects of one supplier failing to deliver the right quality and quantity of products on time.

10.4.4 Strategic Risk

Strategic risks include incidents where a supplier chooses not to adhere to the specifications of the focal firm, for example, when the supplier favours another customer over the focal firm (Schiele et al., 2021). Car manufacturers need many types of supplies, which differ in their costs and the supply risk. If the supply risk is high, for example, if not many suppliers can deliver your desired product, then the supply type is on the right side of Kraljic's matrix (Kraljic, 1983). It is difficult, if not impossible, to find other suitable suppliers for the type of product the company desires if its current supplier decides to supply the focal company's competitor instead of the focal company itself. One option for the company to reduce strategic risk is building a solid relationship with its supplier and becoming a preferred customer.

Following social exchange theory, a supply partner must consider three essential elements as a priority buyer: customer attractiveness, supplier satisfaction and preferred customer status (Hüttinger, Schiele, & Schröer, 2014). In the automotive industry, these three elements are mainly influenced by operative excellence, relational behaviour, growth opportunity and reliability (Hüttinger et al., 2014). Therefore, improving in these areas could result in your company being considered and handled as a priority buyer (Hüttinger et al., 2014). In a global supply shortage, being a preferred customer could mean that the focal company receives the scarce resources available instead of its competitor. Becoming a preferred customer, therefore, diminishes the likelihood that your supply is disrupted and is thus a preventive measure. Moreover, being considered and handled as a priority buyer could enhance innovation, especially in the car manufacturing industry (Schiele, 2012).

However, a supplier may also want to avoid resources to establish a collaborative relationship with a buyer. For example, suppose a company forms a relatively small part of the supplier's customer base. In that case, the supplier might hesitate to invest resources in building a close relationship with the customer. Another possibility is redesigning the product to become less dependent on a supply type. Take, for example, chips. As explained before, only 11% of chip production is bought by automotive companies (Mohammad et al., 2022).

Therefore, suppliers may supply larger customers during a chip shortage instead of the relatively small car manufacturers. During the chip shortage, several car manufacturers, including BMW, redesigned their vehicles and diminished the number of features necessitating chips (Mohammad et al., 2022). They thereby reduced the impact of the chip shortage. Hence, redesigning the product is a reactive measure to enhance resilience. Suppose another chip shortage occurs in the future, and the chip supplier decides to lower the number of chips supplied to the car manufacturer. In that case, BMW will experience a lower impact.

10.4.5 Key Takeaways

Table 1 shows an overview of the preventive and reactive measures discussed above, which firms in the automotive industry can implement to enhance the resilience of their global supply chain. The effectiveness and the possibility of implementing each measure may depend on, amongst others, the type of supply. For example, as explained above, implementing multiple sourcing may be challenging for strategic supplies. This is because only a few suppliers for strategic supplies (Kraljic, 1983) exist.

Table 1. Key Takeaways on Measures to Enhance Supply Chain Resilience

	Preventive Measures	Reactive Measures
Environmental Risks	Supply Chain Mapping	Scenario Planning
Financial Risks	Supplier Credit Assessment	Trade Credit Insurance
Operative Risks	Strong Relationship with key supplier	Strong Relationship with key supplier
	Supplier Development	Redesign Product
	Supply Chain Visibility	Multiple Sourcing
Strategic Risks	Preferred Customer	Redesign Product

10.5 Conclusion

Globalisation has resulted in the increased length and complexity of the automotive supply chain, which makes these supply chains more vulnerable to disruptions. Therefore, it is imperative to enhance the resilience of supply chains in the automotive industry and mitigate disruptions effectively. Hence, the research question studied is: *"How can firms in the automotive industry improve the resilience of their global supply chains to supply chain disruptions?".*

To enhance the resilience of the supply chains in the automotive industry, research was conducted to identify the types of supply risks contributing to disruptions, explicitly focusing on environmental, financial, operative and strategic risks. The critical distinction between these supply risk types is that three are unique to individual firms (financial, operative and strategic risk). At the same time, the other affects many companies in a broader sense (environmental risk).

In pursuit of supply chain resilience, various measures can be employed, distinguishing between preventive and reactive strategies. Automotive companies must conduct a thorough assessment of the risks they face. This assessment serves as a foundational step, enabling the formulation of preventive and reactive measures designed to enhance supply chain resilience and mitigate risk effectively in the future. A preventative measure for environmental risks is to map the supply chain. On the other hand, preventive measures for financial, operative and strategic risk include performing supplier credit assessments, building a solid relationship with key suppliers, improving supply chain visibility, engaging in supplier development, and becoming a preferred customer. A reactive measure for mitigating environmental risks is scenario planning. For mitigating financial, operative and strategic risks, reactive

measures include purchasing trade credit insurance, building a solid relationship with key suppliers, redesigning the product, and implementing multiple sourcing.

10.6 Discussion

More research is needed to fully comprehend supply chain resilience and grasp all measures to improve supply chain resilience in the automotive industry. Current literature mostly mentions the automotive industry as the industry it has been known for over the past 50 years. There is, however, an ongoing significant change in the industry, namely the introduction of electric vehicles. This significant shift in operations has a major impact on the supply chain. Supply chains will likely be redesigned, and measures to enhance resilience may be considered. More research is needed to determine which measures are especially effective to improve resilience in a supply chain that is changing its supply base. Nevertheless, the research provided can be seen as a proper foundation for ongoing research, including research into the electric transformation of the automotive supply chain.

Moreover, the study does not address Industry 4.0, which holds significant relevance for companies in the automotive industry today. Future investigations could explore various facets of Industry 4.0 and their potential integration into the automotive supply chain.

Furthermore, future research could focus on a single source of risk and work out different measures to build resilience to the specific supply risk in more detail. Lastly, future research could focus on how firms in the automotive industry can implement these measures.

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