SUPPLY CHAINS IN GLOBAL AND LOCAL CONTEXT

Effects of global and local sourcing

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ABSTRACT

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Supply chains in global and local context: Effects of global and local sourcing

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Sustainability has become important modern business world. Companies are facing pressure from external parties such as customers and other stakeholders but also from government. Not only the economic sustainability is seen important but also role of social and environmental sustainability has increased. Sustainable supply chains play significant role in company's sustainability and well established and managed supply chains can create competitive advantage.

This thesis is focused on studying sustainability of supply chains from point of view of local and global sourcing of case company Metso. Thesis consists of literature review where theory of supply chains and their sustainability aspects are studied. Other part of the thesis is conducted as case study where the effects of local and global sourcing are reviewed from the sustainability point of view.

The key results show that by comparing sourcing locations, significant reductions in costs and emissions can be achieved. Global sourcing provides wider supplier base, but it can increase lead times compared to local sourcing. It is worth of noticing that the effects are depending on the end customer country and the sourcing location, and the sourcing location should be decided taking into account all the aspects of sustainability.

TIIVISTELMÄ

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Toimitusketjut globaalissa ja paikallisessa kontekstissa: Globaalin ja paikallisen hankinnan vaikutukset

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Kestävyydestä on tullut tärkeä osa modernia kaupankäyntiä. Yritykset kohtaavat paineita tulla kestävämmiksi ulkopuolisilta tahoilta kuten asiakkailta ja muilta sidosryhmiltä mutta myös esimerkiksi hallitukselta. Taloudellinen kestävyys on nähty tärkeänä, mutta nykypäivänä sosiaalisen ja ympäristön kestävyyden rooli on kasvanut. Yrityksen kestävyydessä toimistuketjuilla on tärkeä rooli ja oikein hallitut ketjut voivat luoda kilpailullista etua yritykselle.

Tämä työ on keskittynyt tutkimaan toimitusketjujen kestävyyttä paikallisen ja globaalin oston näkökulmasta case-yritys Metsolle. Työ rakentuu kirjallisuuskatsauksesta joka käsittelee teoriaa toimitusketjujen taustalla sekä kestävyyden aspekteja. Työn toinen osa koostuu case tutkimuksesta, joka käsittelee paikallisen ja globaalin hankinnan vaikutuksia kestävyyden näkökulmasta.

Tulokset osoittavat, että vertailemalla hankinta lokaatioita voidaan saavuttaa merkittäviä vähennyksiä kuluissa sekä päästöissä. Globaali hankinta pystyy tarjoamaan enemmän toimittaja vaihtoehtoja, mutta toimistusajat pidentyvät verrattuna paikalliseen hankintaan. On kuitenkin huomionarvoista, että hankinnan vaikutukset riippuvat hankinta- ja kohdemaasta ja kaikki kestävyyden osa-alueet tulisi ottaa huomioon hankintalokaatiota valittaessa.

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SYMBOLS AND ABBREVIATIONS

Abbreviations

CSR	Corporate Social Responsibility
GrSCM	Green Supply Chain Management
EUR	Euro
LT	Lead time
NA	Not available
NGO	Non-Governmental Organization
OEM	Original Equipment Manufacturer
SCM	Supply Chain Management
SDG	Sustainable Development Goal
SSCM/SuSCM	Sustainable Supply Chain Management
TPL	Third Party Logistics

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1 Introduction

Roots of supply chain management are in the 1950s when companies began to pay attention to the logistical strategies but the concepts which enabled the logistical development take place back in the 1700s. These concepts were anticipation, reactivity, reliability, continuity and standardization and they are key concepts even today in logistics. Nowadays, supply chain management plays key role of company's strategic importance because it can enable adaptation in markets. Supply chain management is seen important, but it should not only include the economic aspects of business. Sustainable supply chain management can be defined so that it manages the three flows of material, capital and information taking into account of economic, environmental and social aspects. (Colin 1996; Paché and Colin 1999; Paché and Colin 2000; Seuring and Müller 2008, according to Morana, 2013, xi, xiv.) Chapter 1 is divided into two sections: 1.1 Background and 1.2 Goal and limitations of the research. First subsection presents the history of supply chain management in general level. Second subsection is focused on explaining the topic, goal and limitations of the research.

1.1 Background

Environmental and social aspects have become important topic for the researchers due raising concern. Focus points for the research have been sustainable development and the ensuring that there would be enough resources for the next generation for utilize. Organizations need to take into account all the dimensions of sustainability, economics, social and environment, in their actions and that way achieve improved products and services. (Elkington 1998; Seuring and Müller 2008; Carter and Liane Easton 2011; Nagariya et al. 2021, according to Kumar, Kumar and Nagariya, 2022, 1332-1333.) This awareness towards environmental aspects was raised by stricter environmental laws and they becoming valid. At the same time researchers started to focus on sustainable supply chains in their research. (Guide et al., 1997; Van der Laan 1997; Krikke 1998, according to Jeong, Jung, and Kim, 2014, 7.) Companies are facing pressure from different stakeholders which

are requiring that companies need to manage their operations from the social and environmental point of view. (Carter, Crum, and Liane Easton, 2011, 47.)

Alongside of the supply chain sustainability it is also important to take into account sustainable sourcing. Its importance has increased in current world both in business and research. Not only lower costs in sourcing needs to be considered by the buying company but also the social and environmental impacts resulting from the behaviour of the supplier. (Hanfield et al., 2005; Koplin et al., 2007; Parmigiani et al., 2011; Walker et al., 2012; Beske and Seuring, 2014; Hartmann and Moeller, 2014; Quarshie et al., 2015; Zimmer et al., 2015, according to Akhavan and Beckmann, 2017, 137.)

Globalization has increased the role of global sourcing and forced companies to rethink structures and strategies on competitive markets. Balance between local and global sourcing is important to be maintained to provide high quality products with lower costs. This balance also enables company's long-term viability. (Zou and Cavusgil, 2002; Townsend, Yeniyurt, Deligonul and Cavusgil, 2004; Kotabe and Mudambi, 2009, according to Cavusgil, Henke and Yeniyurt, 2012, 351.) To ensure long-term survival of supply chain, sustainability and resilience of the supply chains are important. Often the economical side of the sustainability is well established but environmental and social aspects have less attention and are often viewed too narrowly. (Cargno et al. 2019; Mengistu and Panizzolo 2022, according to Baldasarri, Cagno, Colicchia, Coppellotti and Negri, 2023, 49 and 52.)

1.2 Goal and limitations of the research

The topic of the thesis is to study sustainability from supply chain point of view and identify effects of global and local sourcing using chosen parts as sample. These parts are used as spare part for equipment which the case company Metso provides and are sourced through Finland and China. The research is focused on comparing the effects of global and local based sourcing from the point of view of economic, social, environment, vulnerability and resilience. Based on that, following research questions can be formed:

- How sustainable supply chains are defined and how do the effects of the supply chains differ between sourcing from China and Finland from sustainability point of view?

- How supply or sourcing logic could be updated based on the comparison of results?

The research consists of literature review and empirical study. Literature review explains the background and current knowledge of the supply chains and their sustainability aspects. Literature is used to find answers to the research questions from the theoretical point of view. Literature review is focused on topics such as supply chain management, sustainable supply chains and resilience of supply chains. Literature review utilizes academic literature such as peer-reviewed articles, conference papers and books. Literature is searched from Elsevier ScienceDirect, Emerald Journals, ProQuest, Springer Ebooks, EBSCO Business Source Complete, Ebook, Central Academic Complete, ResearchGate, LUTpub and Madison Academic Press. Other sources are possibly utilized if they are seen applicable, for example statistics.

Empirical part of the research is more focused on studying effects of global and local sourcing of spare parts in Metso and in that way study also the sustainability of supply chains. The research is expected to produce comparison of the effects from two different sourcing location. The results of the research can be utilized as a background information for supply or sourcing updates or based on the results evaluation tool for similar situation could be developed. Results are mainly for company's use only.

The report is divided into 8 sections. Following section 2 is focused on the theoretical framework from the supply chain management point of view including basic theory of supply chains and sustainable supply chain management. Section 3 is aiming to give an overview of the case company and section 4 explains the used methods for the in empirical part. Sections 5 is focused on presenting the results from the empirical part and section 6 is focused on discussion. Sections 7 and 8 are drawing conclusions and summary of the research.

2 Theoretical framework

Supply chains are important part of the company's business. Requirements of markets needs to be met, and company should be able to deliver responsiveness and efficiency to customers in right ratio. If the customer's requirements are efficiently fulfilled, it is more profitable to the company. By bringing the best value to the customer, company's supply chains create demand for their services and products. By adapting new technologies and techniques, companies can build supply chains which create profit to them. (Hugos, 2018, 1, 4-5.) Section two is focused on presenting the theoretical background for the research and consists of three sub sections. Sub section 2.1 is focused on explaining the general theory about supply chain management. Section 2.2 goes more in the details regarding sustainable supply chain management. Last sub section 2.3 gives an overview of role of suppliers in supply chain sustainability.

2.1 Supply chain management

Market trends have changed, and end-customer's role has become more significant. Nowadays customers are not only looking for improvements in the services and provided goods but also lower prices. Customers are looking for experience when it comes to buying and not only the product is valuated by the customer anymore. This experience involves communication between the customer and company regarding the service, product and after sales service. Interest towards impacts of the consumption has increased and customers are more and more interested about the economic, personal, societal, and environmental well-being. (Richardson 2010, according to Min, Smith and Zacharia, 2019, 46.)

Supply can be defined as network which consist of multiple companies. These companies are involved in this network though upstream and downstream links. Upstream is seen as supply and downstream is seen as distribution activity. Value is provided to the end customer through different processes and activities which form products and services for the customer to utilize. (Christopher 1992, according to the DeWitt, Keebler, Mentzer, Min, Nix, Smith and Zacharia, 2001, 3.)

Traditionally supply chain has been seen as static system which can be defined per its surroundings. Traditional supply chain consists of direct or indirect parties which aim to same goal: to satisfy the need and requirements of customer. Supply chains are often operated by managers and supply chain management has been seen way to gain value for organization. (Nilsson and Gammelgaard 2012; Fawcett and Waller 2013; Christopher 2016; Chopra 2019, according to Wieland, 2021, 59.)

Other way of seeing the supply chain is as an organic system which is connected to the surrounding environment. This differs from the traditional supply chain in a way that it is not maintained to be fixed to an optimal state. If one part of the supply chains changes it affects to the whole supply chain. Supply chain could be seen as socio-ecological system where the connection between environment and society is recognized. (Westley et al., 2002; Biggs et al., 2010; Nilsson and Gammelgaard, 2012 according to Wieland, 2021, 60.)

Supply chains need to develop in fast pace because of globalization and competitive markets. Globalization has changed the supply chains because of global sourcing activities (Jia et al., 2014, according to Blome, MacCarthy, Olhager, Srai and Zhao, et al., 2016, 1697). Nowadays companies are more and more focused on certain operations what they do best. This leads to situation where companies need to evaluate operations where their competencies are and what would make more sense to outsource to other companies. (Hugos, 2018, 20.)

Depending on the field of acting, supply chains do require different things to be taken into account. The core of supply chains remains the same: it is collaboration between different entities and producing goods to customers (Burritt and Schaltegger, 2014, 232). Those different requirements can lead to a situation where the needs can cause a conflict between the supply chain actors. The balance can be found if the supply chain requirements are not seen separate parts but rather part of larger context. In the supply chain management, it is necessary to focus on improvements in customer service segment and in internal operations and their efficiency. (Hugos, 2018, 5.) In Figure 1 the aspects of customer service and internal operations are presented.

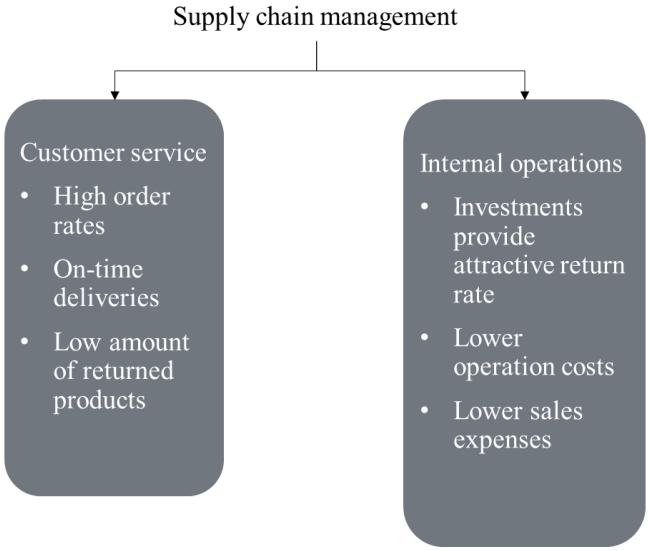

Figure 1. Customer service and internal operation aspects (Hugos, 2018, 5).

In general, the customer service segment aims to high order rates, low amount of returned products and providing on-time deliveries for customer. Internal operation of supply chain management is more focused on gaining profit from investments and other assets and at the same time lowering the operation costs and sales expenses. (Hugos, 2018, 5.) Supply chains can be typically divided into two categories: market responsive and efficient type. Market responsive type us used for innovative products. Efficient type is usually used for functional products (Fisher 1997, according to Blome et al., 2016, 1706.) Supply chains face uncertainty depending on the internal aspects, but also external occurrences cause uncertainty. These uncertainties touch all members of the supply chain. Internal causes of uncertainty can be for example material quality. External causes can be natural disasters and changes in market. (Flynn, Lu and Koufteros, 2016, 4.)

2.1.1 Actors in supply chains

A simple supply chain consists of the company, suppliers, and the customer. If the supply chain is extended, there is three more participants which are part of the supply chain with the company, suppliers, and customer. Compared to simple supply chain, in the extended supply chain there is the supplier's supplier and on the other end of the supply chain is the customer's customer. Third group is service providers. Roughly it can be stated that every

supply chain has producers, distributors, retailers, customer, and service providers. (Hugos, 2018, 23.)

There is no certain limit for number of participants which can be part of the supply chain, and they can play different roles within the supply chain. Over time the participants of the supply chain can change but the needs of the chain for stability remains same. (Hugos, 2018, 27.) Sometimes the supply chain can be disturbed by various reasons and the usually the member which is affected by the disturbance decides not to belong to the supply chain anymore or finds its way to cope in the change. (Flynn et al., 2016, 5).

Every member of supply chain is independent actor and may simultaneously belong to several supply chains. Members act based on their own interests, and they come from different bases. This means that there are differences between the members when it comes to motivations, culture, resources, and structure. These factors create challenges in supply chains. (Dunning, 1995; Goia and Thomas 1996; Thompson, 1967; Hult, 2004; Ireland and Webb 2007; Hult et al., 2007; Hult 2010, according to Flynn et al., 2016, 5.)

2.1.2 Action areas of supply chains

Although every supply chain has its own aspects because of different challenges and demands of market, there can be found five areas where supply chain operations effect. These areas of operations have a trade-off between responsiveness and efficiency. Main activities are production, inventory, location, transportation and information. (Hugos, 2018, 5-6.)

First activity is production which covers capacities of plants, balancing workload, maintenance of equipment and control of quality. Production activity tries to find out what kind of products are needed on market and how much these products should be produced. Companies try to forecast the demand, but it can not be done in a way that it is fully accurate (Chang and Warren Liao, 2010, 527). Responsiveness can be achieved by flexibility in manufacturing, excess capacity and having smaller sized factories. On the other hand, efficiency can be achieved with not having excess capacity, centralized plants and with more narrow focus. (Hugos, 2018, 5 and 11-12.)

Inventory activity is focused on how much stock there should be covering the products but also raw materials. Inventory is used as protector of supply chains against uncertainties which is targeted to supply chains, especially sales losses. (Chang and Warren Liao, 2010, 527). Main inventory related decisions are made based on cycle inventory, safety inventory and seasonal inventory. If responsiveness is sook, inventory levels should be high and range of items wide. If efficiency is preferred, inventory levels should be low and number of items lower. (Hugos, 2018, 12-13.) For inventories, optimal state should be determined taking into account supply and demand requirements, transportation and inventory capacities. Inventory is considered to affect not only to economic aspects but also to social and environmental aspects therefore covering all dimensions of sustainability. These are important aspects when thinking about sustainability of logistical activities. (Mallati and Sowlati, 2018, 805.)

Location activity defines the location for the supply chain operations, for example for production facilities and storage. Decisions related to locations in supply chain are important because they determine where the customer is served (Melo, Nickel and Saldanha-da-Gama 2009, 401). It also considers the cost-efficiency and whether old location can be utilized or are new ones needed. In location activity supply chain related locations are determined for each operation and it is closely related to the trade of between the efficiency and responsiveness. Efficiency can be achieved by having centralized locations but if responsiveness is desired there should be more locations closer the customers. (Hugos, 2018, 13-14.) Taking into account location and transportation enables formation of sustainable supply chains and are therefore important action areas related to supply chains (Battani et al., 2014, according to Becerra, Mula and Sanchis, 2022, 1).

Transportation activity aims to define the transportation modes for moving the inventory to other supply chain location. Transportation also considers the uncertainty of certain modes, for example costs and transit times. Routes and transportation modes are decided by managers based on the locations where the facilities are. In that sense selection of location is important in supply chain management because properly selected location can affect to the total costs (Melo et al., 2009, 401) If the value of the product is high the focus should be on responsiveness. If the value of the product is low, the focus should be on the efficiency. Responsiveness can be enabled with frequent transportation, fast pace, and flexibility. Efficiency can be achieved by transportation with bigger load and using cheaper modes of transportation. (Hugos, 2018, 14-15.) Together with warehousing, transportation is

considered to be the major source of carbon dioxide emissions and other environmental issues related to the logistical activities. (Arkani et al., 2014, according to Becerra et al., 2022, 1).

Fifth activity is information which is focused on data collection. Data which is collected can be used in decision making and coordination. Accurate data affects to all the other activities because the decisions related to the activities are done based on the collected data. Company's ability to gather and analyse valid and reliable data is important for the company because it can improve the overall performance (Yang, 2010, according to Harland, 2024, 76). Information and data are mainly used for coordinating daily operations and forecast future activities or planning. Good responsiveness requires accurate data which is collected and shared on time. Efficiency can be achieved by lowering the cost information at the same time as other cost increases. (Hugos, 2018, 16.)

2.1.3 Supply chain operations

Supply chains often have four main operations which are planning, sourcing, making and delivering. These operations are defined based on the five areas of actions which are used as design parameters, and they shape the supply chain and its capabilities. (Hugos, 2018, 42-43.) In more detailed the supply chain operations can be said to be procurement, forecasting, production, distribution, inventory, logistics and serving the customer. All operations related to the supply chains can be approached from different starting points such as tactic, operational or strategic. (Chang and Warren Liao, 2010, 527)

First operation is planning which consists of series of activities, used to plan, and organize supply chains. Inventory management, forecasting and pricing are part of planning operations. (Hugos, 2018, 42-43.) Nowadays, supply chain planning needs to take into consideration more than such cost reductions meaning that sustainable supply chain planning is taking into account all aspects of sustainability when making supply chain related decisions (Decker et al., 2012, according Boukherroub, Guinet, Fondrevelle and Ruiz, 2014, 181). Services and products need inputs to be created, and these inputs are got through operations such as procurement, credit, and collections. Effective sourcing usually improves the efficiency of supply chain. (Hugos, 2018,42.) It seen important part of supply chains because it is responsible for example of supplier base and obtaining the materials together

with purchasing (van Weele, 2009, according to Rijpkema, Rossi and van der Vorst, 2014, 496).

The operation of making is used to create products or services that are provided through the supply chain. Operations related to the making are designing of the product, scheduling of the product, and managing the facility. Last operation is delivery. Delivery operation consists of order management, scheduling delivery and return process. (Hugos, 2018, 43-44.) From sustainability point of view, logistical operations are important since they are relying on fossil fuels, affect negatively to health of residents', increase pollutions and use non-renewable natural resources (Abbasi and Nilsson, 2016, 274).

2.1.4 Evolution and life cycle of supply chain

Often life cycle is related to products, but life cycle thinking can be also utilized in supply chains (Blome et al., 2016, 1698). There are four phases which can be recognised in life cycle of supply chain. These phases of the supply chain life cycle are illustrated in Figure 2.

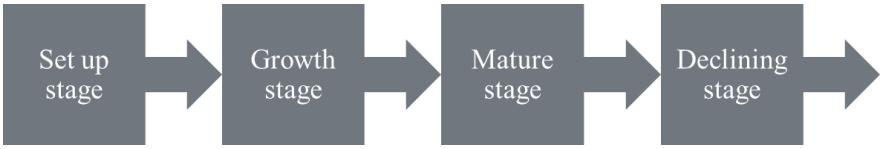

Figure 2. Stages of supply chain life cycle (Blome et al., 2016, 1700).

First step of the supply chain life cycle is the setting up the supply chain. At the beginning there may be several supply chain options which develop during time, but it is not impossible that some of the supply chains do not develop further. After the setting up period, the next stage is growth stage. During this growth stage the supply chain is getting more stable because of improvements and more usage. Also enabling technologies is typical characteristic for growth stage. When the certainty reaches a certain level and demand is on stable level due strong processes and technologies. When this stage is reached, it can be said that supply chain is on mature stage. During mature stage, changes regarding supply chains

are quite small. Last stage is declining, which is caused by decreased throughput, for example replacing supply chains or decreasing markets. (Blome et al., 2016, 1700.)

Life cycle of supply chain can be assessed using Life Cycle Assessment (LCA). LCA can be conducted in more limited version or in full version. Limited version of LCA can be conducted using different boundaries, for example only examining the upstream from certain point of the supply chain, examining the downstream on certain point of supply chain and examining part between two chosen points of supply chain. Full version of LCA includes detailed information about used raw materials and other inputs such as energy in every stage of supply chain and in addition detailed information about the outputs of the supply chain. (Tan and Culaba, 2002, according to Allen, Anderson, Browne, Keïta and Rizet, 2005, 762.)

Evolution and emergence of supply chains is driven by six main factors which are procurement and sourcing, technologies and innovations, competition and markets economics, supply chain strategy, legislative aspects such as policies and regulations, and re-engineering. Technologies and innovation can change existing supply change or create new ones. One aspect which leads to this kind of change is lock-in situations which cause disruptive change. Market's development and declining can affect to supply chains by quickly developing them or changing other way. (Ellram et al., 2013, according to Blome et al., 2016, 1708.) It would be important to companies to understand the relationship between supplier and customer and how it fits to the whole supply chain system. Companies need to take into account the industry specific aspects and sourcing strategies which would support the companies' ability to stay competitive and cope with technological change. (Aoki,1988; Womack et al., 1990; Van Kooij, 1991; Minato, 1992; Oliver and Wilkinson,1992; Sako,1992; Pickernell,1997; Esposito and Passaro,1998, 2007; Takeishi, 2001; Bianca and Esposito, 2007; Marshall et al., 2007, according to Esposito and Passaro, 2009, 114.)

2.1.5 Supply chain risks

Constant introduction of new products increases the uncertainty companies face. Usually demand uncertainty increases but also requirements for wider range for products, customization or for technology can cause uncertainty to the supply chain, for example delays in delivery or production. These lead to situation where less standardization exists for products and services but there are more new products introduced to the markets. These act

as drivers for supply chain complexity and increasing supply chain risks. If company face disruptions related to the supply chain, it can cause lost in sales, reputation loss and poorer financial performance. (Fisher, 1997; Lee, 2002; Tang, 2006; pwc and MIT, 2013, according to Saranga and Sreedevi 2017, 332.) Poorly managed supply chain risks can cause poor product quality, faulty forecasting, lower turnover, poor relationships with other parties and conflicts among the shareholders (Cousins et al., 2004, according to Christopher, Khan, Mena and Yurt, 2011, 68.)

There are four main categories recognized for supply chain uncertainty which are supply, demand, technology, and manufacturing. Demand uncertainty is one of the main uncertainty types and it often comes from the unknown characteristics of new products. Also manufacturing and supply can create uncertainty. Uncertainty increases when manufacturing and procurement processes become more complex. Supply chain risk, flexibility and environmental uncertainty are closely linked to each other. Environmental uncertainty is linked to manufacturing process risk, supply risk, and delivery risk. Supply, manufacturing and delivery risks are depending on size of the company, intensity of competitiveness and mitigation of preventive risks. (Davis, 1993; Randalla and Ulrich, 2001; Ho et al., 2005; Calantone et al., 2010, according to the Saranga and Sreedevi, 2017, 332-333.)

Complex global supply chains create challenges and affect to the reliability of supply chain. Companies and suppliers involved in the supply chain compete against other companies and suppliers and seek the customers attention. Companies need take time for try to identify the possible risk related to the supply chains and document the risk management process. Once the risks are identified, companies may find ways to decrease those risks. Disruptions which supply chain can face during the life cycle are often unexpected which affect to the normal flows. (Dust, 2019; Helmold and Terry 2021, according to Dathe, Flouris, Helmond and Yilmaz, 2022, 3 and 5.)

Risks can be generally categorized in two categories: internal and external risks. Internal risks are risks which one can control and external risks are out of one’s control. Internal risk drivers include five main types of drivers which are manufacturing risk, business risk, control and planning risk, contingency and mitigation risk and cultural risk. Manufacturing risks occur in operations and process of company and are caused by disruptions. Business risk can occur if there are changes in management, business processes, key personnel or reporting. Control and planning risk are often due the in effective planning and assessment.

Contingency and mitigation risks can occur of in problem situation there is no proper contingencies put in place. Cultural risks can be caused by tendency to hide unpleasant information. (Dathe et al., 2022, 5-6.)

External risks are driven by five main drivers which are supply risk, demand risk, business risk, physical plant risk and environmental risk. Demand risk can be caused by customer or end-customer demand which is misunderstood by the company. If there occur any disruptions in the supply chain, for example in flow of materials, the risk is called supply risk. Environmental risk are due external factors which can be related to governmental, climate, economic and social factors. If supply chain face supplier related issues for example financial or managemental instability, the risk can be called business risk. Last risk driver is physical plant risk which are due the condition of facilities or regulatory factors. (Dathe et al., 2022, 5-6.)

Nowadays multinational firms are broadening the markets abroad. This happens especially in areas where demand for high quality products is increasing. Governments policies have impact on companies sourcing strategies because government can adjust for example tariffs. Tariffs can be used to make domestic or local sourcing in other words more appealing to companies. If company finds it attractive to source products overseas with higher quality, it can still do that but suffers from the tariff burden. In domestic sourcing the risk is quality spillover which might decrease the profits. On the other hand, it can improve the quality of domestic manufacturers' products. Many companies expose themselves to the risk because in that way they can avoid the burden. (Sanghvi et al., 2011, according to Chen, Mu and Niu, 2019, 2509.)

Many products do have global markets and companies tend to find mix between local and global shoring. Policies and regulation have affected to the supply chains. For example, financial crisis, economic and political factors do shape the existing supply chains. Phenomena of local sourcing, sourcing from the low-cost location, and global sourcing have shaped supply chains from the sourcing point of view. Lastly, supply chain strategies and re-engineering which are used because of changing marketing environment. Supply chains strategies and re-engineering are solutions if markets need to be served better, operations or cost performance needs to be improved, or new possibilities require investigation. (Ellram et al., 2013; Gereffi, 2014, according to Blome et al., 2016, 1708-1710.)

If sourcing is done locally, the efficiency increases because of the possibility of one-stop-purchasing. This might decrease the cost of unit sourcing. Local suppliers are often more stable and can be managed and monitored closely (Pan and So, 2010, according to Guan, Xiao and Yin, 2017, 1-2.) On the other hand, local supply chains are lacking elasticity. Lack of elasticity comes from factors such as natural disasters, gap in technology, trade ban and epidemic control. (Haroon, 2021, according to Ma and Zheng, 2022, 202.)

Risks and advantages are depending on the location. For example, if the sourcing company is located in developing country, the sourcing cost may be lower if sourced locally. On the other hand, if the sourcing is done overseas, more high-quality material can be sourced. Local sourcing can benefit developed countries with more advanced technologies and overseas sourcing lower costs. (Yeniyurt et al., 2013, according to Guan et al., 2017, 1.)

Global supply chains can face supply or demand shocks which cause risk to the chain. These shocks are usually sectoral or geographical. Supply shock can for example come from labour strikes, natures disasters, cyber-attacks, accidents in industry, bankruptcy of suppliers or political instability. Demand shocks can be caused by bankruptcy of customer, competitors, changes in markets, economic crisis, volatility of exchange rates or company reputation or product damage. Services and products can suffer from different shocks. On the other hand, it can be thought that risks are not only to global supply chains but also from the global supply chains. All structures include the risk, but global sourcing affects to domestic country by exposing it to foreign shocks. (Heiland and Ulltveit-Moe, 2020; Miroudot 2020, according to Baldwin and Freeman 2021, 5.) When companies stop being fully domestic, evaluating the possible risks become harder (Aabo, Pantzalis, Sørensen and Toustrup, 2016, 1298).

Other risks related to global sourcing are lower net profits because of hidden costs, problems in quality, know-how losses, poor infrastructure and communication, increase of transport, lead times are longer, progress of work is higher, inventory of safety, lost sales, poor responsiveness, instability from political point of view, differences in culture and time, social responsibility, fluctuation on exchange rates, difficulties in coordination, uncertainty when it comes to demand and impacts on long term. (Markides and Berg, 1988; James, 1990; Fagan, 1991; Levy, 1995; Braithwaite, 2003; Trent and Monczka, 2005; Ellegaard, 2008; Liu et al., 2008; Tsai et al., 2008; Andersen and Skjoett-Larsen 2009; Mollenkopf et al., 2010, according to Christopher, Khan, Mena and Yurt, 2011, 67-70.)

There are certain benefits of global supply chains. These benefits are for example lower costs, better flexibility and higher speed, better quality, new technologies and markets and better access to them, resource availability, improving competition in domestic base of suppliers, regulatory and political environments for supply chains are improved. (Fagan, 1991; Humphreys et al., 1998; Monczka and Morgan, 2000; Lowson, 2001; Ettlie and Sethuraman, 2002; Trent and Monczka, 2003; Zeng, 2003; Preston, 2004; Liu et al., 2008; Tsai et al., 2008, according to Christopher et al., 2011, 70.) In addition, companies which are international, can manage the risk by modifying structures of costs and revenues utilizing offsetting manner. This is something domestic companies can not do. (Aabo et al., 2016, 1297.) According to the research conducted to Scandinavian non-financial firms by Aabo et al. (2016, 1298) the companies which use foreign suppliers can mitigate the corporate risks because foreign supplier network offers flexibility and protects the company against unexpected currency value fluctuations by diversifying locations of currency flows.

Risks related to the supply chains can be prevented and mitigated. One solution is to decrease the amount of supplier involved in the supply chains. If there are more suppliers, the risk of disruption increases. Disruptions can lead to waste, decrease in sales, and cost recovery. Lack of operational slack and surplus can lead to negative stock effects which on the other hand can lead to situation where shareholder value and stock process can be varied by supply chain disturbances. Supply chain disturbances can cause stops or standstills in manufacturing. Supply chain risks can be prevented and mitigated by diverse capacity management so there is smaller possibility to the situation with lack of supplier capacity. Diverse capacity management can for example be having different location for manufacturing or back-up equipment. (Ellram and Liu 2002; Helmond and Terry, 2021, according to Dathe et al., 2022, 6-7.)

Other solution tackling with supply chain vulnerability is supply chain flexibility. Vulnerability can be reduced by supply chain designing but designing can also increase the vulnerability. Flexibility is seen as solution to the uncertainty faced by supply chains. Better performance in business can be achieved if supply chains are able to be flexible in uncertain environments. Mitigating supply chain risks with flexibility is difficult because it is not well-known that what kind of flexibility is needed and how much of it is required. That is why it is important to companies to identify and test under various contexts what kind of flexibility

is needed to reduce the uncertainty. (Martínez Sánchez and Pèrez Pèrez, 2005; Tang and Tomlin, 2008; Merschmann and Thonemann, 2011, according to Saranga and Sreedevi, 2017, 333.)

Supply chain related disruption situations can be identified as following: capacities which are inflexible, issues in transport, shortages in capacity, launches of new products, issues in labour, lack of transparency, instabilities in pricing, market capacity, transfer of products and disasters. It is important to companies to identify the dependent and independent variables which are related to the supply chains. It is also important to consider the relationships. Together these can help management to recognize the most important factors for effective risk mitigation. After company decides what aspects, they find important to be evaluated, suppliers' performance can be evaluated. There are many possible practices to evaluate the performance, for example reviews of third-party, site visits, ratings, contacting suppliers' customers, supplier questionnaires (web based or paper) and audits. (Dathe et al., 2022, 7-8.)

There are two core concepts when thinking the recovery from a shock. Resilience means ability to plan, act and recover from disturbance which organization and its supply chains face. Robustness is ability to be able to maintain the certain operations during the disturbance. Robustness requires redundancy if the supply chain involves many external suppliers or sites to produce the product. Aspects which can help to ensure the resilience of a supply chain are for example buffer stock, standardized inputs and designing the supply chains so that supply chain related risks are taken into account. Both robustness and resilience have a trade-off between the decentralization of risks and lower cost and high-quality of inputs. Sometimes company needs to investigate that can they focus on both robustness and resilience. This kind of situation could be that there are only few suitable suppliers which means that robustness is not possible because company is tied to the few suppliers. Resilience on the other hand requires close co-operation between the company and supplier so that trust can be achieved. (Bode et al., 2011; Brandon-Jones et al., 2014; Simchi-Levi et al., 2014; Sàenz and Revilla, 2014; Imchi-Levi, 2015; Dubey et al., 2017; Martins de S´a et al., 2019, according to Baldwin and Freeman, 2021, 8.)

Building a resilient supply chain is based on four main steps which are supply chain collaboration, supply chain engineering, agility and culture of supply chain risk management (Christopher and Peck 2004, 7). These are presented in Figure 3.

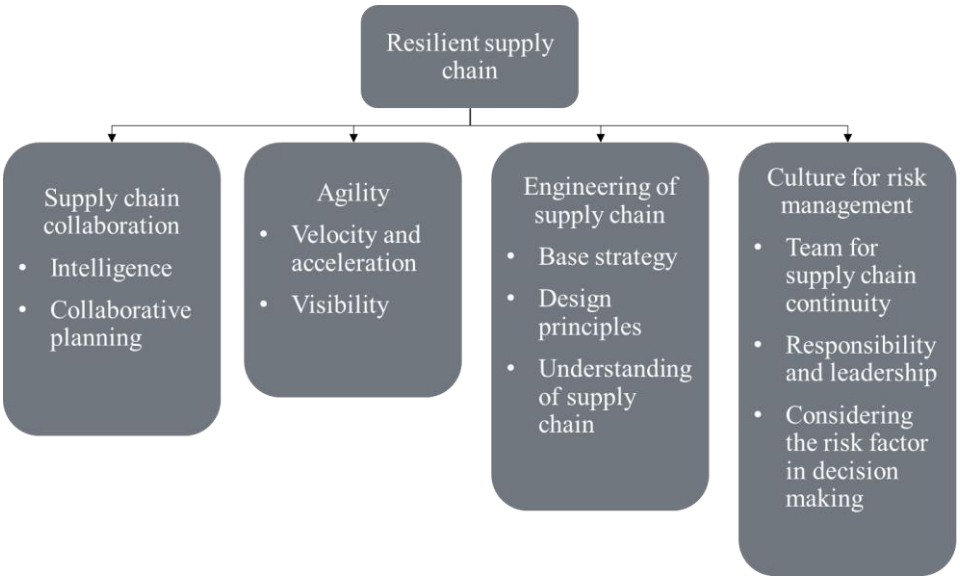

Figure 3. Resilient supply chain (Christopher and Peck 2004, 7 modified).

Supply chain engineering means the designing the supply chain considering risks. Understanding supply chain focuses that the relationships between company and other actors in supply chain are understood, it can for example include analysis of critical path and mapping and risk register. Supply base strategy means the selection of suppliers and amount of them. It also includes sourcing decisions and criteria and supplier development. Two supply chain design principles are both selection of supply chain strategies and examination of efficiency and redundancy. These principles are used to achieve the resilience. Supply chain collaboration is needed to build the resilient because effective collaboration between actors in supply chain can help mitigating the risks. Supply chain collaboration consists of collaborative planning and supply chain intelligence. (Christopher and Peck 2004, 7-9.)

Agility means ability to respond unexpected situations, for example changes in demand or supply. Supply chain visibility means the capability to see the whole supply chain. This means that for example demand, inventories, production, and schedules can be seen. Other aspect of agility is supplying chain velocity, it is defined as time used for certain distance, for example how much time it takes to move product from other end of the supply chain to other. Last part of resilient supply chain is the culture for risk management. It includes

consideration of factor risk, leadership and responsibility and teams for continuity of supply chain. (Christopher and Peck 2004, 10.)

2.2 Sustainable supply chain

Today's companies face external pressure for example from government, society, and stakeholders to take into account other aspects than only the economic side. It means that supply chains and actors involved in them should include also the environmental and societal aspects. Because of certain existing barriers, companies struggle in implementation of sustainable supply chain management. These barriers can be due coordination complexity, costs and communication difficulties. (Paché and Colin 1999; Paché and Colin 2000; Seuring and Müller, 2008, according to Morana, 2013, xiv.)

Sustainable organization must implement triple bottom line (TBL) in their business if they want to be referred sustainable. TBL includes all the aspects if sustainability: economic, environmental, and social. Company must be economically viable, socially responsible, and environmentally friendly. (Elkington, 1998 and 2004, according to Hales, Kwon, Yalcin and Yun, 2019, 141.) Sustainable supply chain consists of responsible sourcing, green practices, and corporate social responsibility (World Bank, 2012, according to Firat, Kara and Yurtsever 2016, 160.)

Economic sector usually involves dimension such as profits, cost and investment. Social dimension includes customers, safety, health, employees and community. Environmental dimension is seen to consists of resource usage, pollution, emissions and waste. All these dimensions would be important to be considered in terms of long-term survival of supply chain. (Cargno et al. 2019; Mengistu and Panizzolo 2022, according to Baldasarri, Cagno, Colicchia, Coppellotti and Negri, 2023, 52.)

Sustainable supply chain management is affected by several factors. Some of the affecting factors are competition, carbon footprint, regulatory, relations with customers, corporate social responsibility (CSR), cycles of production and delivery and sustainable development goals (SDGs). Research of sustainable supply chain management has led to situation where strategies for reduction of pollution, waste, raw materials and other challenges regarding sustainability are recognized. (Agrawal et al., 2022, according to Anholon, Castillo Apraiz,

Dippern, Gornati, Lambrechts, Leal Filho, Morello, Paulino Pires Eustachio and Viera, 2023.) Sustainable supply chain includes its' all members from supplier to the customer (Jeong et al., 2014, 8).

Due globalization, production of goods has taken place all over the world. This has caused the situation where the social and environmental impacts are taking place in the locations where the consumption does not necessarily happen. The role of supply chains in sustainable global economy has been highlighted by the United Nations' SDGs. It is also addressed that supply chains play key role in tackling with social and environmental struggles. Companies are more committed to improve their supply chains to be more sustainable but overall understanding of actions which enable the improvement is lacking. (UNCTAD, 2013; Chakravorti, 2017, according to de Zegher, Lambin and Thorlakson, 2018, 2072)

Sustainability is defined as following *"meeting the needs of the present without compromising the ability of future generations to meet their own needs."* This definition has its roots in 1987, when United Nations Brundtland Commission defined it. Sustainable development does not only include the environmental side but also the development from the economic point of view. (United Nations, n.a.)

Sustainable development includes 17 goals which together form a framework. All in all, sustainable development goals are focused on decreasing the effects of human actions of climate change worldwide. The 17 goals are presented below (United Nations, n.a. a; United Nations, n.a. b.):

- No poverty
- Zero Hunger
- Good health and well-being
- Quality education
- Gender equality
- Clean water and sanitation
- Affordable and clean energy
- Decent work and economic growth
- Industry, innovation and infrastructure
- Reduced inequalities

- Sustainable cities and communities
- Responsible consumption and production
- Climate action
- Life below water
- Life on land
- Peace, justice and strong institutions
- Partnership for the goals

If supply chain is considered to be sustainable, the management of it includes integrating the environmental and social aspects to every step of the supply chain. The focus is to mitigate the negative impacts to environment, social and economic aspects which supply chain activities can cause. While mitigating the negative impacts the long-term value is maximized. (Gupta and Palsule-Desai, 2011; Shekarian et al., 2022, According to Anholon et al., 2023.) Aspects of sustainable supply chain management are presented in Figure 4.

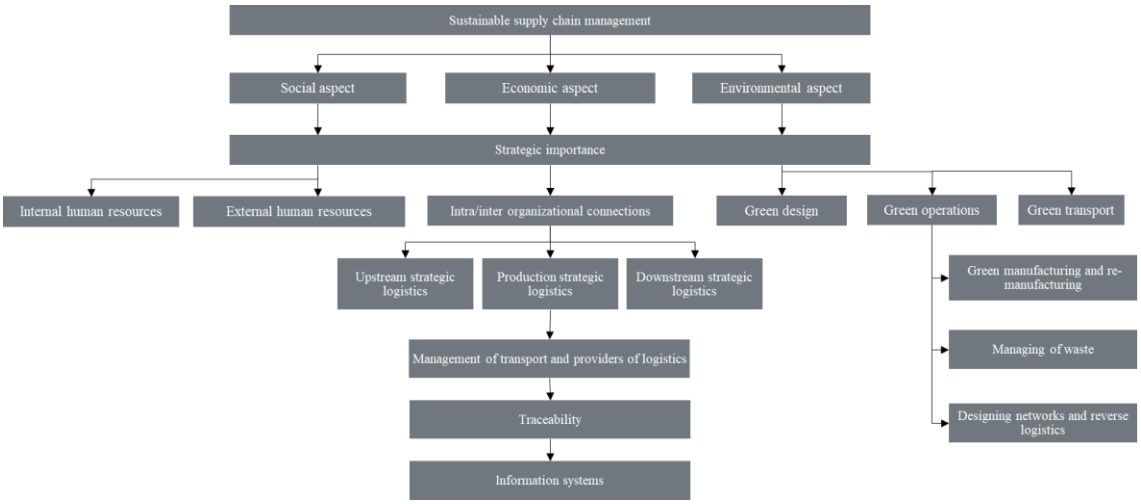

Figure 4. Aspects of sustainable supply chain management (Morana, 2013, 11, 58, 111, modified).

Sustainable supply chain management consists of economic, environmental and social dimensions. These dimensions include various aspects. (Morana, 2013, 11, 58, 111.)

Sustainable supply chain management dimensions are explained in sections 2.2.1, 2.2.2 and 2.2.3 in more detail.

Sustainable supply chain management is aiming to decrease the consumption of energy, generate less waste, and decrease the production of greenhouse gas emissions. This can be achieved by utilizing renewable energy, recycling, and using transportation options which are considered eco-friendly. Other goal is that entire supply chain includes safe working conditions, fair labour, proper wages. In addition, consideration of human rights is crucial. Thirdly, sustainable supply chain is aiming to provide economic viability for all stakeholders. These principles drive the sustainable supply chain management. (Anholon et al., 2023.)

If the aim is sustainable supply chain, then all members of the supply chain need to work closely together. This includes suppliers, customers, and other stakeholders. Sustainable supply chains require adaptation the sustainable development goals. On the other hand, adaptation of the sustainable development goals needs commitment from companies and willingness to change the ways of working, for example by re-engineering processes. Companies need to ready to mitigate their negative impacts and at the same time providing life for the coming generations. (Campagnolo et al., 2018; Khan et al., 2021; Cammarano et al., 2022; According to Anholon et al., 2023.)

2.2.1 Economic sustainability

Value which economic segment provide for sustainable supply chain can be presented as supply chain profitability. This profitability comes from the difference between the overall cost from the whole supply chain and cost coming from consumers. Activities that company conducts need to be profitable if long term sustainability performance required (Slaper and Hall, 2011, according to Rausch-Phan and Siegfried, 2022, 19). Sustainable supply chain management from economic point of view is based on intra – and inter-organizational collaboration. Logistics related to upstream strategy, downstream strategy and production strategy are strongly related to intra- and inter-organizational connections. These are managed from the point of view of transport and logistics providers. Also, traceability is related closely to the management of economic side of sustainable supply chain. (Morana, 2013, 11.) From the sustainability point of view, it can be said that economic side of

sustainable supply chain is related to the activities which can cause profit to the company (Arowoshegbe and Emmanuel, 2016, according to Rausch-Phan and Siegfried, 2022, 19).

In upstream strategy supplier usually plays the key role. There can be identified three different roles of supplier which are Purchasing management, Purchasing marketing and Supplier portfolio management. Downstream strategy, on other words production strategic logistics, is related to lean production. Lean production is used to maximize the load of equipment but at the same time bringing down the inventory. (Ohno 1989; Giard, 2003; Paché, 2006, according to Morana, 2013,11-13, 22-23.)

Distribution strategic logistics is strongly related to the concern regarding the durability and making sure that the customer proves that they can be partners in a long-term. Distribution strategic means that there is link between marketing and distribution. It is recognized that logistics is necessary part of marketing and marketing is relying on it. Strategic management of transport is essential part of flow of goods. Strategic transport management consist of role of urban logistics spaces which is related to the connection between highway network and destination location. The strategic role of logistics providers is increasing. They provide goods which they own but also of goods owned by other companies. In addition, the role of traceability can not be overlooked, and it has important role in logistics. In supply chain context, traceability refers to the ability to find the history for example of a certain product. Well established traceability creates opportunity to withdraw product if any problems occur. (Aurifeille, 1997; Senkel, 2002, according to Morana, 2013, 27, 30, 34, 38-39)

Last aspect of the economic dimension of the sustainable supply chain management is the information and information system. Intra- and inter-organizational connection can not function properly without required amount of information. To get the proper information, the information systems must be put in place. Information systems provide resources such as software's, hardware, store, communication, and human resources. (Reix, 1995, according to Morana, 2013, 44.) All in all, economic sustainability aims to achieve cost savings and improve the profitability. In addition, also establish viability of their stakeholders. (Anholon et al., 2023.)

Economic performance consists of two categories: risk management and transparency. Risk management includes planning of being prepared, supply disturbances, supply chains which deliver outwards. Transparency consists of engagement among stakeholders and operations

of suppliers. (Carter, Crum and Easton, 2011, 48.) Economic performance can be measured taking into account following aspects: improvement in production, financial benefits and market share growth. (Zailani et al., 2015; Yang, 2017, according to Gashi, Kraslawski and Qorri, 2020, 9.)

There are three types of practices which can promote the sustainable supply chain management which are lean, green, and resilient practices or paradigms. These practices cover all three dimensions of sustainability: social, economic, and environmental sustainability. Lean practices mean elimination of waste, just-in -time and total quality management. Green practices mean cleaner production, ISO 14001 standard and reverse logistics. Resilient practices are flexible transportation and sourcing and risk management. (Azevedo, Carvalho, Cruz-Machado and Govindan, 2014, 216.)

2.2.2 Social aspects

Social and societal aspects are important when thinking about organization's performance. These aspects are highlighted especially in of supply chain and green supply chain management. If these aspects are ignored, it can lead to situation where processes are failing, organizations become inappropriate and problems in teams, for example demobilization and dysfunctions. (Grlt, 1995; Cooper et al., 1997; Lambert, 1998; Bowersox, 1999; Mentzer et al., 2001; Min, 2004; Lambert, 2005; Emeric Levy of CPIM-APICS, 2007, according to Morana, 2013, 108.)

Corporate Social Responsibility is important to companies to implement in their business. CSR was earlier more motivated by the societal aspects than economical. Nowadays it is expected that CSR goes beyond the economic and legal aspect of the company. (Bowen, 1953; Carroll and Shabana, 2010, according to Jesus Saenz, Koufteros, Luoma and Meixell, 2015, 72.) Social and societal aspect of sustainable supply chain management can be divided into internal human resources and external resources. Internal human resources consist of rights or individuals, work satisfaction, organizational commitment, and identification. External human resources mainly consist of aspects which can be seen from outside of the company, such as company image, reputation, attractiveness of company. In addition, external partners and support from unions are seen as part of the external resources. (Morana, 2013, 112.) In general way the social aspects of sustainability are aspects which bring

benefits to the society, for example fair wages, improved working conditions, health care and prevention of accidents (Rausch-Phan and Siegfried, 2022, 20).

Individual rights are based on the Social Accountability standard SA8000, and it is important part in social responsibility and supply chains. It consists of nine areas which are, forced and compulsory labour, disciplinary practices, child labour, health and safety freedom of association and the right to collective bargaining, working hours, discrimination, remuneration and management systems. Individual rights also include code of conduct and social balance. Second aspect of internal human resources is satisfaction of work. Satisfaction of work consists of working conditions. interest, autonomy, and career prospects. (Cilberti, 2008, according to Morana, 2013, 112-114.)

Organizational commitment is related to the transactional exchange. It brings together employees and employer. Organizational commitment is formed by consensual investment evaluating, training provided by company or education, competences, capabilities, and motivation. Organizational identification means the feeling of employee when thinking belonging to the organization. If employee can identify being part of the organization, one can define the identity of the organization. (Dem, 1997; Chedotel, 2004, according to Morana, 2013, 116, 122.)

External human resources include company's attractiveness. It is related to the opportunities of learning which are offered by the company. Mostly it means the company's capability to learn and develop from its' own experiences. Second part of the external human resources is reputation and image. Company's image can be based on traceability and applying different standards, for example ISO 14001 which is environmental standard. Last aspect is support from external partners and unions. All members of supply chain are important and support from these partners and unions are crucial. (Mintzberg et al., 1999; Boiral, 2004; Karâa, 2010, according to Morana, 2013, 126-129.)

Social performance consists of culture in the organization. The culture is formed from aspects such as ethics and values, culture's roots which are deeply ingrained and citizenship of the organization. (Carter et al., 2011.) Social performance can be measured from the point of view of well-being of stakeholders, safety while working and health of community. (Peng and Lin, 2008; Paulraj et al., 2017, according to Gashi, 2020, 48.) Globalization has affected to supply chains in a way that activities has spread culturally diverse locations where the

practices can differ from the organization's values. This can cause issues, for example higher tolerance for corruption or tendency to favour something. That is why assessment of social sustainability is important not only for the company but also for their suppliers and customers. (Mani and Gunasekaran, 2018; Villena, 2018, according to Fracarolli Nunes, Lee Park and Machuca, 2023, 36.)

2.2.3 Environmental sustainability

Business which produces their products with short life cycle is not sustainable. These products usually end up being disposed into landfills or being incinerated. Not recycling raw materials some of the materials can end up running out, for example zinc. Most of products are produced using non-renewable materials or resources, which makes the disposal difficult. To achieve long lasting products, recycling and recovering the non-renewable materials is important implementation to business. One way to improve the sustainability is to sift from typical supply chain to closed loop supply chain (Cohen, 2007, according to Ferguson and Souza, 2021, 2.)

Closed loop supply chain differs from the typical supply chain in the way that the direction of flow can be from customer to manufacturer because of possibility of return. There are three main types of returns. First is customer return which means that customer return slightly used product. Second type of return is end-of-use returns which refers to returns where product belongs to older generation but is used for longer time and it is still usable. Third type is end-of-life return which are returns where the product has achieved the end-of-life stage of its life cycle, and it is used for material recovery. Next step for the retuned products can be one of the following options: landfilling, incineration, recycling, harvesting of parts, resale, reuse internally or manufacturing/refurbishment. (Realff et al., 2004; Ferguson, 2006, according to Ferguson and Souza, 2010, 3-4.)

Companies have started to try to find a way to go from simple waste management more towards waste re-engineering. This process starts from the early stage of the production process. One key concept of sustainable supply chain management is green supply chain management which has its roots in 1990s. Green supply chain management can be defined as applying thinking of environmental aspects into supply chain management. This kind of environmental thinking can be implemented in a form of emission reductions, waste

management and taking into account biodiversity (Chin et al., 2015, according to Ajmal, Dhir, Jabeen, Khan and Talwar, 2023, 1604). This environmental thinking should be applied into all steps of the supply chain process. (Srivastava, 2007, according to Morana, 2013, 53.)

Green supply chain management consists of three elements which are importance of green supply chain management, green operations, and green design. Pressure from customer side has enabled the shift towards green supply chain management (Ahmed et al., 2019, according Ajmal et al., 2023, 1604). When thinking importance of green supply chain management, managers' and stakeholders' role is important. The goal is to find the competitive advantage is found in approaches which are considered to be value-creating, responsive and anticipatory. Green operations include the actions such as reverse logistics, designing networks, managing of waste, manufacturing, and remanufacturing. Green supply chain management consists of sustainable decisions made in design, procurement, processes, materials, delivery and post-delivery management (Çankaya and Sezen, 2019; Moduli et al., 2020, according to Ajmal et al., 2023, 1064). Green operations have four main concepts which are linking internal operations and remanufacturing, recognizing the effects of competition in segment of remanufacturing, adding processes of designing products, returning products and bonuses, implementing reverse logistics and remanufacturing to the supply chain. (Srivastava, 2007, according to Morana, 2013, 55-57.)

If green thinking is wanted to be applied into business, one of the first things to take into account is green design (or eco-design). Green design starts from the point where the methods which use least resources need to be identified and put environmental management in place. The actual product design is done maximizing the reusability of the parts at the end-of-life stage of the product. Green designing utilizes same approaches as used in life cycle assessment. One key aspect of thinking in green design is eco-efficiency, which aims to the following things: to reduce intensity in materials, reduce intensity in energy, reduce amount of toxic substances, improve services, extend life cycle of products, increase amount of using renewable resources and increase the recyclability. (Gherra, 2005; Ademe, 2006; Reyes Carrillo, 2007; Berneman et al., 2009, according to Morana, 2013, 58-59.)

Green manufacturing and remanufacturing aim to recover products and materials, reduce, recycle, do inventory management, and produce, schedule and plan. Other aspect of green operations is waste management. Waste can be categorized in various ways, for example municipal waste, non-hazardous industrial waste, packaging waste, industrial waste,

hazardous waste, toxic waste, and organic waste. On other words, waste is categorized based on the origin of it or properties. Third aspect of green operations is reverse logistics. Reverse logistics means in general that material or good is returned because of reuse, recycling, or disposal activity. Green logistics (which is part of reverse logistics) and reverse logistics are related to following areas: reduce traffic, maintenance of energy and material, using land efficiently, reducing pollution to air, water, and visual pollution, reduces odours and noise, manages solid and hazardous waste. (Carter and Ellram, 1998; Rogers and Tibben-Lembke, 2001, according to Morana, 2013, 64-73.)

Green transportation can be defined as an opportunity for company to use different transportation mode when aiming to decrease the amount of environmental pollution from transportation. Companies are encouraged to utilize rail, river, or sea transportation instead of air or road transportation. The reason for this is that air and road transportation are considered to be heavy polluter when comparing to rail, river or sea transportation. (Morana, 2013, 85.)

If lean, green, and resilient practices are considered from the point of view of environmental sustainability, less aspects are related to it when compared to economic sustainability. Lean or green practises which are related to environmental sustainability are just-in-time, cleaner production, ISO 14001 standard and reverse logistics. Only resilient practice affecting is flexibility in transportation. (Azevedo et al., 2014, 216.)

2.3 Role of supplier in sustainability and sustainable sourcing

Supplier sustainability is considered important because its determinates how sustainable the company is. When the supplier's performance regarding sustainability aspects is poor, the supplier can be replaced with other supplier, or they have opportunity to improve their skills. Developed suppliers benefit company mostly indirectly but also development benefits suppliers' operational performance. By developing environmental and social performance of supplier, company's employees' satisfaction can be improved. (Calantone, Krause, Scannell, 2000; Klassen, Krause and Vachon, 2009; Ehrgott et al., 2011, according to Gualandris and Kalchschimdt, 2016, 2472.)

Alongside the importance of overall sustainability, importance of sustainable sourcing has increased due industrialization. Companies are seeking cost reductions, financial performance and competitive advantage by sustainability. Although many positive effects can be gained from the sustainability, also concerns have been raised. These concerns are mainly related to safety from environmental point of view, challenges in security, welfare in labor and open operations in business. (Thomas et al., 2016; Foo et al., 2018, Bueno-Garcia et al., 202, Dai et al., 2021; Schulze et al., 2022, according to Masood, Rehman, Shahzad and Zafar, 2024, 78.)

The cost reduction point of view in sourcing might be problematic because it increases the risk to choose non-sustainable materials over sustainable ones. Due the fact that consumers are nowadays willing to pay more for products which are sustainable and raising demand from stakeholders' side companies are taking the social and environmental impacts into account in their sourcing activities. Sustainable sourcing practices means the inclusion of the economic, social and environmental aspects into the sourcing activities alongside the standard practices such as delivery, pricing and quality. This means taking into account long-term partnership between byer and supplier, sharing mutual sustainability goals, verifying suppliers and suppliers' engagement with environmental legislation. (Chen, 2008; Rogetzer et al., 2018; Dai et al., 2021; Mungkung et al., 2021; Rehman et al., 2023, according to Masood et al., 2024, 78-79.)

Because company's supply chain performance is depending on the supplier's performance, the selection of supplier is critical for the company. It is ideal to find suppliers, who share similar goals and interests regarding sustainability aspects and development. Evaluation of supplier's sustainability considers the same triple bottom line as the supply chain sustainability. It is also considered that this evaluation includes other aspects such as risk management, strategies, transparency, and culture in organization. (Carter, 2011; Amindoust et al., 2012; Chaharsooghi and Ashrafi, 2014; Luthra et al., 2017, according to Arhin, Khan, Kusi-Sarpong and Kusi-Sarpong, 2018, 964, 966.) In Figure 5 aspects which are used in supplier sustainability performance evaluation are illustrated.

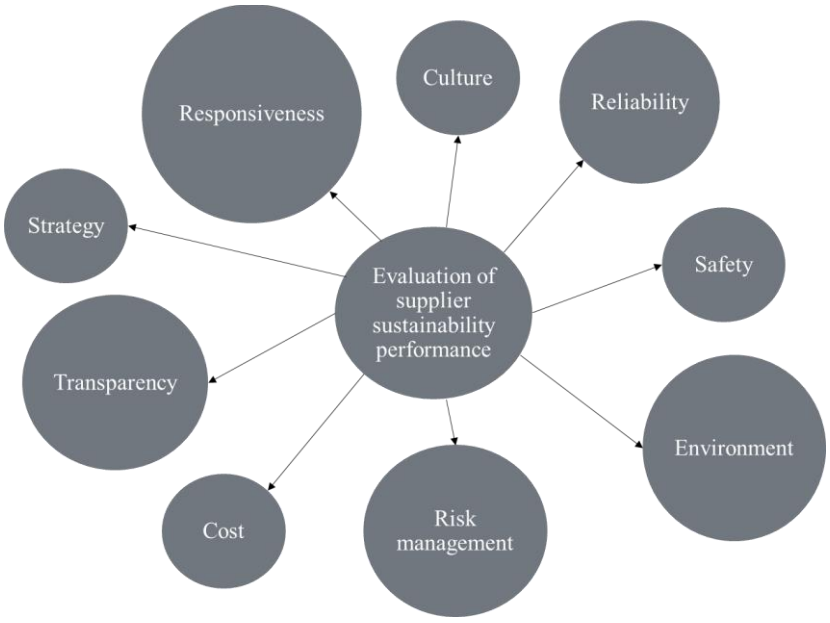

Figure 5. Aspects of supplier sustainability performance evaluation (Carter, 2011, according to Arhin et al., 2018, 966).

Selection of supplier should consider sustainability aspects. In sustainable supply chain management, the selection of supplier is important, because it can affect the performance and robustness of the supply chain. Selection of sustainable supplier is complex and includes various aspects of sustainability. Traditionally the selection has been based on economic aspect, but inclusion of social and environmental aspects has become important. Other considered aspects are for example lead times, social responsibility, implication of cost and quality. (Zhu et al., 2007; Bai and Sarkis, 2010; Chaharsooghi and Ashrafi, 2014; Trapp and Sarkis, 2016; Song et al., 2017 Gören, 2018; Mohammed et al., 2018, according to Arhin et al., 2018, 966.)

The expectation regarding supplier sustainability can vary a lot depending on tier of supplier. For example, in European Union, there are regulations which are targeted towards companies which have direct connection to customer rather than companies that do not have direct connection. Suppliers who are not in contact with the end customer, are hardly touched by these regulations. The implementation of sustainability to business by the suppliers differs from the original equipment manufacturers (OEM). This is due the fact, that regulations and pressure from consumers are more targeted to the end of the supply chain from the supplier

point of view. (Green et al., 1996; Siegel, 2009; Lo, 2013, according to Azadegan, Foerstl, Hartmann and Leppelt, 2015, 68-69.)

3 Introduction of empirical part

Section 3 is focused on giving short overview of the case part of the research. Section is divided into two subsections: 3.1 introduces the case company and 3.2 illustrates the frames of the case parts.

3.1 Company introduction

Case part of this research is conducted to Metso Finland Oy. Metso is global company which offers services, technologies and end-to-end solutions in fields of minerals processing, aggregates and metals refining all over the world. Metso employs over 17 000 people in almost 50 different countries. In 2023 Metso's sales were 5,4 billion euros. (Metso, 2024a.)

Metso's business is driven by electrification, urbanization, sustainability and scarcity of resources and artificial intelligence and digitalization. Main purpose of Metso is to enable modern life by offering sustainable solutions in the field of industry the company operates. Metso's vision is that they are first choice for customer when it comes to sustainable use of natural resources and in that way be valuable partner to work with. Metso's brand promise is that they will be "partner for positive change". (Metso, 2024b; Metso, 2024c.) Metso's core values and top priorities are presented in Figure 6.

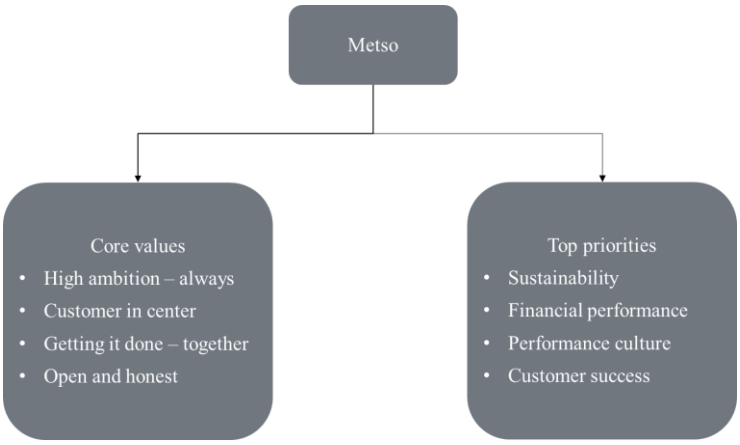

Figure 6. Metso's values and priorities (Metso, 2024c).

Metso has Planet Positive portfolio which includes over 100 products. When comparing these Planet Positive products to previous generation products or industry benchmark, they are more water and energy efficient. By utilizing Planet Positive products customer can cut their carbon dioxide emissions directly and indirectly through manufacturing and delivering being less carbon intense and increasing the opportunity to recycle. By 2030 Metso aims that they spend 80% of research and development on Planet Positive development. When it comes to Metso's own operations, they are aiming to be net zero by 2030. (Metso, 2024c.)

Metso has updated their sustainability agenda in 2023. The updated agenda consist of following areas: offering Planet Positive products and innovations, environmental efficiency, Metso's culture and people and responsible supply chains. Environmental footprint is aimed to be minimized through reduction of environmental impacts from company's own operations, procurement and logistics. Well-being and safety of people is seen priority in Metso. Customers are helped to reduce risks, increase productivity and efficiency regarding environmental aspects by offering Planet Positive solutions. Metso finds it important to take into account social, environmental and economic aspects in their value chains and they work closely with their suppliers. (Metso, 2024d.) Plans of actions, long-term plans and targets of Metso are formed according to United Nations Sustainable Development Goals. (Metso, 2023.)

3.2 Goal and scope

In Metso, various actions in social, environmental and economic areas are important and it is enabled with close collaboration with suppliers through value chain. Actions against climate change, fair employment, operating safety, identification of risks and carefulness are seen as priority. Sustainability of suppliers is assessed in the beginning by Metso. Registration and completion of supplier profile is essential for all Metso's suppliers and also agree Metso Supplier Code of Conduct. Corrective actions are required from the supplier if Metso's requirements, for example safety practices or anti-corruption policy, and supplier's answers do not meet. Metso aims to help their suppliers to improve their sustainability performance through education and advising. (Metso, 2024e.)

Metso wants to reduce their emissions generating from logistical operations by 20%. They also aim that 30% of supplier spend is with partners that have emission targets based on science. Both of these goals are planned to be executed before the end of year 2025 and reduction is done using year 2019 as a baseline. (Metso, 2024d.)

Goal of the case part is to gather data from Metso and investigate the sustainability aspects of supplying selected parts using chosen supply chain types based on whether the sourcing is local or global. After data gathering, results can be compared in terms of cost, lead times, resilience, vulnerability, social and environmental aspects. Results can be used internally in Metso for example for updating supplying logic and to give and frame how to assess supply chain sustainability. This research does not present detailed results because that would require release of internal confidential information.

Case part includes comparison of environmental, economic and social aspects in parts which was applicable. Economic aspects include costs of parts, lead times and transportation. Environmental aspects include emissions from transportation and other data regarding warehousing. Social aspects include health and well-being of Metso's employees and business relationship with the suppliers. In addition, case part includes resilience aspect, which includes security of delivery and vulnerability of supply chains. System under investigation is illustrated in Figure 7.

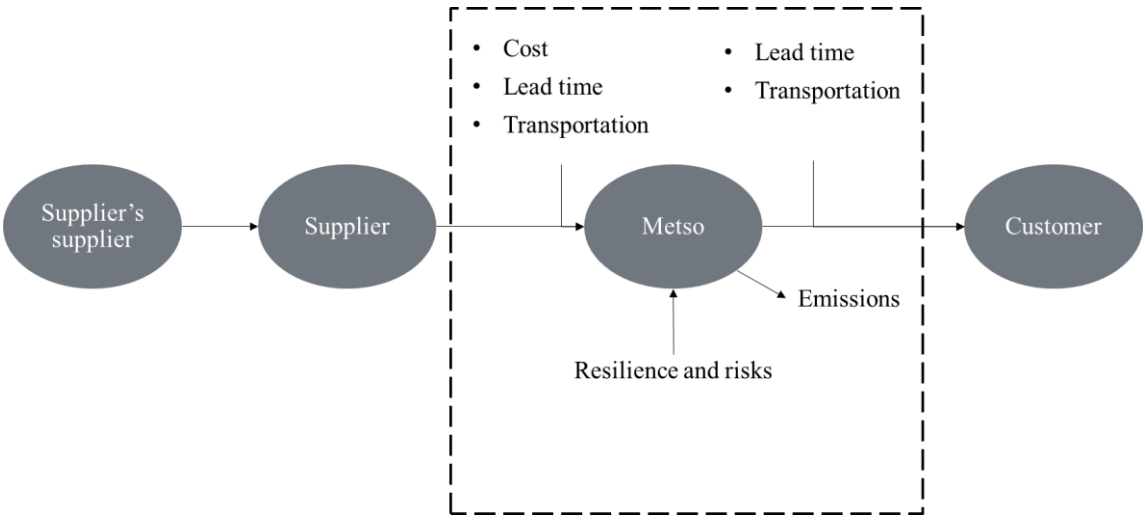

Figure 7. System boundary.

Some of the supply chain related information is excluded. This kind of information is for instance supplier and customer related information such as names, exact costs and lead times and locations, packaging costs, warehousing costs and emissions from offices and packaging. Supplier and customer names, locations, exact costs of parts and lead times are excluded because they are internal confidential information. Packaging and warehousing costs are excluded because it is not possible to calculate those per one item. This is due the fact that in the warehouse multiple different parts are stored and handled and packaging can include several items at once. Also, information regarding suppliers' suppliers is excluded due the lack of available information. Overall, exact numerical values are not presented. Values which are presented are mainly average values or value ranges.

This research is focused on investigating supply chain sustainability using selected parts as an example. These parts belong to filter equipment. Two types of parts are selected in this case study to get variance to the results (costs and lead times) because the functions of these product groups are different. Selected valves are presented in Table 1. Specific part related information, for instance costs and lead times, are not presented.

Table 1. Selected valves (Metso, 2024f).

Valve number	Description	Valve number	Description
Valve 1	Butterfly valve	Valve 11	Solenoid valve
Valve 2	Butterfly valve	Valve 12	Directional valve
Valve 3	Butterfly valve	Valve 13	Directional control
Valve 4	Control valve	Valve 14	Pressure reduction valve
Valve 5	Check valve	Valve 15	Throttle check valve
Valve 6	Directonal valve	Valve 16	Counter balance valve
Valve 7	Flow control valve	Valve 17	Check valve
Valve 8	Ball valve	Valve 18	Pressure relief valve
Valve 9	Ball valve	Valve 19	Ball valve
Valve 10	Proportional valve	Valve 20	Relief valve

In this research 20 different valves were selected as a sample. Different kind of valves were chosen so that variation between the suppliers, costs and lead times was possible to get. In addition to valves, also electrical parts were considered. Basic function with these valves is same. These parts are presented in Table 2.

Table 2. Selected electrical parts (Metso, 2024f).

Electrical part number	Description	Electrical part number	Description
Electrical part 1	Cable clamp	Electrical part 11	Relay
Electrical part 2	Cable clamp	Electrical part 12	Circuit breaker
Electrical part 3	Analog input module	Electrical part 13	Analog input module
Electrical part 4	Analog output module	Electrical part 14	Digital input
Electrical part 5	Interface module	Electrical part 15	Safety relay
Electrical part 6	Digital input	Electrical part 16	Miniature circuit breaker
Electrical part 7	Digital output module	Electrical part 17	Battery
Electrical part 8	Digital output module	Electrical part 18	Memory card
Electrical part 9	Output relay module	Electrical part 19	Digital input module
Electrical part 10	Contactor relay	Electrical part 20	Interface module

In this research 20 different electrical parts were selected as a sample. Different kind of electrical parts were chosen so that variation in supplier related aspects such as costs, lead times and transportation are possible to achieve. These chosen parts do have different functionalities which affect to the supplier selection and therefor difference in results can be generated.

Metso uses four kinds of supply chains in their business. The type of supply chain depends on the sourcing location and buying location. First scenario is that the customer location buys from local vendor. Supply chain is illustrated in Figure 8. MA in the figures is shortened from market-area. (Metso, 2024g.)

Figure 8. Local supply chain (Metso, 2024g, modified).

Second scenario is that customer location buys from global vendor. This kind of supply chain is presented in Figure 9. (Metso, 2024g.)

Figure 9. Global supply chain (Metso, 2024g, modified).

Third type of supply chain is that customer facing location buys from global stock. This supply chain type is presented in Figure 10. (Metso, 2024g.)

Figure 10. Global stock-based supply chain (Metso, 2024g, modified).

Fourth supply chain type is where customer facing location buys from virtual plant. This supply chain is presented in Figure 11. (Metso, 2024g.)

Figure 11. Virtual plant-based supply chain (Metso, 2024g, modified).

Not every of these supply chain types are used in this case because the type highly depends on the supplying location, end location and the part which is supplier. (Metso, 2024g.) In this research selected market areas are China, central Europe and United States. Because of these market areas, supply chains resemble of an example illustrated in Figures 8, 9, and 11. These market areas are chosen because variation in supply chains were sought and by selecting these areas it can be provided. Also, differences between lead times between the sourcing location and end country are seen interesting regarding these countries. Parts are sourced both locally and globally. From the selected parts some of them are going hypothetically to China only and some of the parts are going to both USA and Europe. This

is based on the idea that the customer for the certain parts is in China and for the rest of the parts customer can be either in USA or in Europe.

4 Methods

In case part, preliminary methods which were used to collect data were primary data collection and gathering existing literature. Primary data in this context means mainly data which is collected directly from Metso. Primary data can be for example numerical data such as lead times and costs but also interview answers and public information from Metso's websites. Literature was gathered from different databases as in theoretical part of this research.

Primary data was collected by qualitative interview and gathering it from public sources. Although primary data is preferred to be collected from public sources, also not public sources are used. These non-public sources are Metso's internal databases. Interviewing is conducted to people who work in Metso. Suitability of interviewees was based on the required data and the role they have in company. Interviews were conducted via Teams, email or if applicable, face to face.

To get the necessary information, contacting several people and teams was required. For example, people from following teams were contacted: tactical sourcing, logistics, supply chain management and sustainability. Questions can be categorized in different categories based on the interviewed teams and theme of the questions. Question categories are sustainability, resilience and vulnerability, logistics and supply chains. Total number of interviewed people was 6. Titles of interviewed employees are presented in Table 3. Before the actual interview, interview questions were sent via email so that it is possible to get to know the questions and the theme of thew interview before. Nature of these interviews were freeform. Interview questions are presented in Appendix.

Table 3. Interviewed employees.

Interviewed	Title
1	Tactical Sourcing Manager
2	Senior Manager, Tactical Sourcing Manager
3	Director, Supplier Quality & Development
4	Senior Manager, Sustainability
5	Senior Manager, Logistics Sustainability
6	Senior Manager, Supply Chain Optimization.

Because personal data is collected during the interview, all interviewed persons have given their consent for the data collection and usage of the collected information. They have been informed using data protection notification form. Form includes information about what kind of information is collected and why it is collected, how it is stored, how long the information is stored, how data is transferred and who is contact person regarding this data collection process.

5 Results

In section 5 the results are focused on economic and environmental aspects of sustainability which are produced from data given by Metso. Other aspects of sustainability are more analysed in discussion.

5.1 Economic

This section is more focused on the economic aspects of sustainability. Section 5.1.1 presents the sourcing related aspects such as lead times and costs. Sections 5.1.2 is more focused on transportation related results including inbound and outbound costs.

5.1.1 Sourcing

In total 40 different parts were used to assess the economic aspects of supply chains. These parts were sourced both locally and globally. Local supplier in this context means that the supplier and buying entity are in the same country. Global supplier in this context is supplier which is in different location than the buying entity. Global and local sourcing can be viewed from end user's point of view but also from the company's point of view. In this research company's perspective is used. Sourced parts and their suppliers are presented in Tables 4 and 5.

Table 4. Suppliers of valves (Metso, 2024h).

Valve number	Supplier	Location	Valve number	Supplier	Location
Valve 1	Supplier 1	China	Valve 11	Supplier 8	Finland
Valve 2	Supplier 1	China	Valve 12	Supplier 7	Finland
Valve 3	Supplier 1	China	Valve 13	Supplier 7	Finland
Valve 4	Supplier 2	China	Valve 14	Supplier 7	Finland
Valve 5	Supplier 3	China	Valve 15	Supplier 7	Finland
Valve 6	Supplier 4	Finland	Valve 16	Supplier 7	Finland
Valve 7	Supplier 5	China	Valve 17	Supplier 5	China
Valve 8	Supplier 6	Finland	Valve 18	Supplier 3	China
Valve 9	Supplier 7	Finland	Valve 19	Supplier 3	China
Valve 10	Supplier 7	Finland	Valve 20	Supplier 5	China

Suppliers in general are located either in Finland or China. Valves were sourced using 8 different suppliers. Half of the suppliers are located in Finland and other half is in China. Valves are sourced mainly from one supplier either from Finland or from China regardless of the end customer country.

Table 5. Suppliers of electrical parts (Metso, 2024h).

Electrical part number	Supplier	Location
Electrical part 1	Supplier 9	Finland
Electrical part 2	Supplier 9	Finland
Electrical part 3	Supplier 10	China
	Supplier 9	Finland
Electrical part 4	Supplier 10	China
	Supplier 9	Finland
Electrical part 5	Supplier 10	China
	Supplier 11	Finland
Electrical part 6	Supplier 11	Finland
	Supplier 10	China
Electrical part 7	Supplier 11	Finland
	Supplier 10	China
Electrical part 8	Supplier 9	Finland
	Supplier 10	China
Electrical part 9	Supplier 10	China
	Supplier 9	Finland
Electrical part 10	Supplier 12	China
	Supplier 13	Finland
Electrical part 11	Supplier 13	Finland
Electrical part 12	Supplier 11	Finland
Electrical part 13	Supplier 14	Finland
Electrical part 14	Supplier 14	Finland
Electrical part 15	Supplier 15	Finland
Electrical part 16	Supplier 9	Finland
Electrical part 17	Supplier 14	Finland
Electrical part 18	Supplier 16	China
	Supplier 11	Finland
Electrical part 19	Supplier 10	China
	Supplier 11	Finland
Electrical part 20	Supplier 10	China
	Supplier 11	Finland

Suppliers of electrical part are located either in Finland or China. Electrical parts had also 8 different suppliers. In total 16 suppliers were used with valves and electrical parts. Some parts do have only one supplier in Finland or China but there are parts which can be sourced from either Finland or China and therefore have two suppliers marked in the table.

Costs, lead times from supplier and lead times to the market areas (United States (USA), central Europe and China) for valves are presented in Tables 6 and 7 and 8. Lead times (LT) are presented in days and costs in euros (EUR). Both are presented as average values and as a range from minimum value to maximum value.

Table 6. Sourcing data for valves going to USA (Metso, 2024h; Metso, 2024i).

Average					
LT Finland	LT China	LT from China to USA	LT from Finland to USA	Average cost from China EUR	Average cost from Finland EUR
46	58	163	115,10	554,88	201,48
Range					
5-190	28-105	133-210	74-259	20,57-3224,64	23,40-813,10

Based on the numerical values, it can be said that sourcing from Finland is faster based on the lead time from supplier to warehouse. The difference between lead times in Finland versus in China do not differ remarkable. When looking the lead times to USA both from Finland and China the difference increases which can be explained by geographical distances between, the sourcing location and end customer country. The main difference in this sourcing location is that costs from China are much higher than from Finland. This can be result from many reasons, for example from the sample size or that the valve sourced from Finland can be same as the valve sourced straight from China.

Sample size effects in a way that in this sample there might be few expensive valves coming from China and the cheaper valves from Finland which distorts the results showing that all valves are expensive from China which in a bigger picture might not be true. Also, there can be situation where same valve is bought by retailer and it is bought as bulk which lowers the cost. From lead time and cost point of view it would be more ideal to source these valves from Finland, but it is worth of noticing that these results are based on small sample size, and it can affect to the results.

Average			
LT Finland	LT China	LT from China to France	LT from Finland to France
46,1	58	164,00	58,1
Range			
5-190	28-105	28-205	17-291

Table 7. Sourcing data for valves going to Central Europe (Metso, 2024h; Metso, 2024i).

Average					
LT Finland	LT China	LT from China to Central Europe	LT from Finland to Central Europe	Average cost from China EUR	Average cost from Finland EUR
46	58	164,00	58	554,88	201,48
Range					
5-190	28-105	134-211	17-202	20,57-3224,64	23,40-813,10

When looking the lead times to Central Europe both from Finland and China, it can be said based on the results that lead time from China is much longer than lead time from Finland with approximately 100 days of difference. That is explained by shorter distances from Finland to central Europe than from China to Central Europe. Sourcing valves to Central Europe sourcing would be more ideal to be done from Finland based on the lead time and cost of valves.

			Average	
LT Finland	LT China	LT from China to China	LT from Finland to China	Average cost from Ch
46,10	58,00	58,00	148,10	554,88
			Range	
5-190	28-105	28-84	15-46	20,57-3224,64

Table 8. Sourcing data for valves going to China (Metso, 2024h; Metso, 2024i).

Average					
LT Finland	LT China	LT from China to China	LT from Finland to China	Average cost from China EUR	Average cost from Finland EUR
46	58	58	148	554,88	201,48
Range					
5-190	28-105	28-105	107-292	20,57-3224,64	23,40-813,10

Examples before having been mainly focusing global sourcing. Based on the results, local sourcing offers shorter lead times than global sourcing to China. Global sourcing provides over 100 days longer lead time than local sourcing. Geographical distances are the main

reason for the shorter lead times and transportation mode can be chosen differently than in case where for example parts need to be transported overseas. Local sourcing is beneficial option in China from lead time point of view but from cost point of view parts are cheaper from Finland.

Costs, lead times from supplier and lead times to the market areas USA, central Europe and China for electrical parts are presented in Tables 9 and 10 and 11. Lead times (LT) are presented in days and costs in euros (EUR). Both are presented as average values and as a range from minimum value to maximum value.

Table 9. Costs and lead times to USA for electrical parts (Metso, 2024h; Metso, 2024i).

Average					
LT Finland	LT China	LT from China to USA	LT from Finland to USA	Average cost from China EUR	Average cost from Finland EUR
16	69	168	95	103,18	95,95
Range					
3-70	28 - 84	128 - 184	73-171	11,35 - 156,42	1,00-208,81

Sourcing electrical parts to USA would be more ideal to be done from Finland than from China based on the lead times and costs. Difference in lead time between China and Finland based sourcing is approximately 70 days. Shorter lead time to USA is due the short lead time from supplier to warehouse. The difference in the cost is not significant.

Table 10. Costs and lead times to central Europe for electrical parts (Metso, 2024h; Metso, 2024i).

Average					
LT Finland	LT China	LT from China to Europe	LT from Finland to Europe	Average cost from China EUR	Average cost from Finland EUR
16	69	168	37	103,18	95,95
Range					
3-70	28 - 84	128-184	15-46	11,35 - 156,42	1-208,81

Sourcing electrical parts to Central Europe, sourcing from Finland is more beneficial based on the cost and lead times. Shorter lead time can be explained by the transportation mode

and distances. Road transport is faster than shipping the parts from China to Central Europe. Also, the distance from Finland in shorter.

Table 11. Costs and lead times to China for electrical parts (Metso, 2024h; Metso, 2024i).

Average				
LT Finland	LT China	LT from Finland to China	Average cost from China EUR	Average cost from Finland EUR
16	69	117	103,18	95,95
Range				
3-70	28 - 84	104-135	11,35-156,42	1,00-193,20

In China, electrical parts can be sourced either from Finland or China. Local sourcing provides shorter lead times because of the distances and road transportation. The difference is mainly based on the number of stages in transportation and travelled distance. From Finland the supply chain goes through at least two warehouses compared to local supply chain in China where one warehouse is forwarding the part to customer.

5.1.2 Transportation

In addition to costs and lead times of the parts, transportation costs were taken into account in economic side of sustainability. These transportation costs are estimations for inbound in Finland and China but also outbounds from Finland and China to the USA and Europe. Estimated costs are based on the weight of the part and do not include packaging. Other way would be estimate based on weight and dimensions. Dimensions are not always available and due that weight-based estimation was used although it is not as accurate as the dimension-based estimation. To get more accurate estimation, mass and dimensions of packaging needs to be known but in this case this information was excluded because it was

not available. For shipping the less than container is used to estimate the cost because individual parts are transported. Transportation is much more complex, and these values are estimated for the sake of comparison.

There are several different incoterm types which define for example risks, costs and obligations (International Chamber of Commerce, 2019, 2). Most used incoterm in Metso is Free Carrier (FCA). In FCA the good is delivered from the seller to byer in one or two ways. If one way delivery is used, the seller carries the risk and pays costs till the goods are moved to be transported and rest of the delivery the risk is carried by the byer. In two-way delivery the risks are carried, and costs are paid till the first stop by the seller and rest of the delivery by the byer. In FCA seller is not obligated to take insurance. Seller needs to provide certain information if it is requested by byer who is obtaining insurance. (International Chamber of Commerce, 2019, 29, 34). In this case it is assumed that the used incoterm is FCA for both inbounds and outbounds. This assumption is made so that the cost of transportation is comparable regardless of the origin because paying entity is chosen to be Finland. Inbound costs are presented in Table 12 and 13. Transportation mode when moving goods inside of one country is assumed to be road. From some supplier the estimation of inbound costs was not able to be done and those are marked with NA in the table.

Table 12. Inbound costs for valves (Metso. 2024h; Metso, 2024j).

Part	From	Transportation cost to warehouse EUR	Part	From	Transportation cost to warehouse EUR
Valve 1	China	NA	Valve 11	Finland	130,00
Valve 2	China	NA	Valve 12	Finland	250,00
Valve 3	China	NA	Valve 13	Finland	250,00
Valve 4	China	NA	Valve 14	Finland	250,00
Valve 5	China	200,00	Valve 15	Finland	250,00
Valve 6	Finland	420,00	Valve 16	Finland	250,00
Valve 7	China	200,00	Valve 17	China	200,00
Valve 8	Finland	130,00	Valve 18	China	200,00
Valve 9	Finland	250,00	Valve 19	China	200,00
Valve 10	Finland	250,00	Valve 20	China	200,00

*NA means that the information is not available

Inbound costs for valves were estimated using estimation based on weight of the part and distance between supplier and warehouse. Inbound from China was approximately 200 euros and from Finland variating from 130 euros or 420 euros. From some supplier the estimation of inbound costs was not able to be done and those are marked with NA in the table. Regarding inbounds in China, there is not significant variation but when comparing inbounds in Finland, the transportation is approximately 290 euros more expensive.

Table 13. Inbound costs for electrical parts (Metso, 2024h; Metso, 2024j).

Part	**From**	**Transportation cost to warehouse EUR**
Electrical part 1	Finland	220,00
Electrical part 2	Finland	220,00
Electrical part 3	China	200,00
	Finland	220,00
Electrical part 4	China	200,00
	Finland	220,00
Electrical part 5	China	200,00
	Finland	130,00
Electrical part 6	Finland	130,00
	China	200,00
Electrical part 7	Finland	130,00
	China	200,00
Electrical part 8	Finland	220,00
	China	200,00
Electrical part 9	China	200,00
	Finland	220,00
Electrical part 10	China	200,00
	Finland	250,00
Electrical part 11	Finland	250,00
Electrical part 12	Finland	130,00
Electrical part 13	Finland	250,00
Electrical part 14	Finland	250,00
Electrical part 15	Finland	130,00
Electrical part 16	Finland	220,00
Electrical part 17	Finland	250,00
Electrical part 18	China	NA
	Finland	130,00
Electrical part 19	China	200,00
	Finland	130,00
Electrical part 20	China	200,00

	Finland	130,00

*NA means that the information is not available

Inbound transportation cost was estimated based on the weight of part. When estimating the cost, it was assumed that parts are delivered individually because parts come from different suppliers. Regarding electrical parts, inbound cost in Finland varies from 130 euros to 250 euros. Inbound costs in China are around 200 euros. Based on these estimations, it can be said that transportation inside Finland can be more expensive when it comes to inbounds compared to inbound costs in China.

In general, can be said that from Finland to China and USA the transportation mode is ocean as well as from China to USA and Europe. From Finland to Europe the transportation mode is most likely road. (Metso, 2024i.) In this research it is assumed that used transportation modes are ocean and road, and no other modes are investigated due the fact that those are not most common options. Presented costs are given as average costs or rounded up depending on the transportation type. For road transportation the estimation is done using average costs but for ocean the cost is rounded up from estimated cost for less than container shipment. Cost is estimated per item and based on the weight of item. Cost for items which weigh under 1 kg is estimated based on the assumption that they weigh 1 kg. The estimation system does not recognize mass which is under 1 kg. Outbound costs from the origins to destination countries are presented in Table 14 and 15.

Table 14. Outbound costs for individually transported valves to USA, Europe and China (Metso. 2024h; Metso, 2024j).

Part	From	To USA EUR	To Europe EUR	To China EUR
Valve 1	China	740,00	470,00	Same as inbound
Valve 2	China	740,00	470,00	Same as inbound
Valve 3	China	740,00	470,00	Same as inbound
Valve 4	China	740,00	470,00	Same as inbound
Valve 5	China	740,00	470,00	Same as inbound
Valve 6	Finland	660,00	1400,00	360,00
Valve 7	China	740,00	470,00	Same as inbound
Valve 8	Finland	660,00	1400,00	360,00
Valve 9	Finland	660,00	1400,00	360,00
Valve 10	Finland	660,00	1400,00	360,00
Valve 11	Finland	660,00	1400,00	360,00
Valve 12	Finland	660,00	1400,00	360,00
Valve 13	Finland	660,00	1400,00	360,00
Valve 14	Finland	660,00	1400,00	360,00
Valve 15	Finland	660,00	1400,00	360,00
Valve 16	Finland	660,00	1400,00	360,00
Valve 17	China	740,00	470,00	Same as inbound
Valve 18	China	740,00	470,00	Same as inbound
Valve 19	China	740,00	470,00	Same as inbound
Valve 20	China	740,00	470,00	Same as inbound

Outbound transportation costs were estimated in two ways. One way was to estimate the cost based on assumption that all the components are transported individually. Regarding valves, it is most likely cheaper to transport the valves from Finland to USA but cheaper from China to Central Europe and inside China. The difference between costs from Finland and China to USA does not differ significantly, but for example to Central Europe the difference is

noticeable. The cost from Finland to Central Europe is almost three times more than from China. Although distance from Finland is shorter to Central Europe, road transportation is more expensive than shipping the parts longer distance. Transportation cost to China is cheaper from China than from Finland but the difference is only 160 euros. Again, the difference comes mainly from the transportation modes and distances.

Table 15. Outbound costs for individually transported electrical parts to USA, Europe and China (Metso. 2024h; Metso, 2024j).

Part	From	To USA EUR	To Europe EUR	To China EUR
Electrical part 1	Finland	660,00	1400,00	360,00
Electrical part 2	Finland	660,00	1400,00	360,00
Electrical part 3	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 4	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 5	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 6	Finland	660,00	1400,00	360,00
	China	740,00	740,00	Same as inbound
Electrical part 7	Finland	660,00	1400,00	360,00
	China	740,00	470,00	Same as inbound
Electrical part 8	Finland	660,00	1400,00	360,00
	China	740,00	470,00	Same as inbound
Electrical part 9	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 10	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 11	Finland	660,00	1400,00	360,00
Electrical part 12	Finland	660,00	1400,00	360,00
Electrical part 13	Finland	660,00	1400,00	360,00
Electrical part 14	Finland	660,00	1400,00	360,00
Electrical part 15	Finland	660,00	1400,00	360,00
Electrical part 16	Finland	660,00	1400,00	360,00
Electrical part 17	Finland	660,00	1400,00	360,00
Electrical part 18	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 19	China	740,00	470,00	Same as inbound
	Finland	660,00	1400,00	360,00
Electrical part 20	China	740,00	470,00	Same as inbound

	Finland	660,00	1400,00	360,00

The outbound transportation costs do not differ between valves and electrical parts. This can be due the size of the parts because mostly the weight of parts is around few kilograms, excluding few exceptions. Regarding electrical parts comparison between whether part should be sourced from China or Finland can be done. In case of USA, it is cheaper to transport the parts from Finland to USA than from China although the difference between the costs is around 80 euros. The small difference is mainly due the transportation mode and similar distances. In case of Europe, it is cheaper to transport the parts from China than from Finland because the road transportation is more expensive than ocean transportation. In China the transportation cost is cheaper than transporting the parts from Finland via ship to China. Distances in China are shorter although more expensive transportation mode is used. Based on the data, it can be said that if same transportation mode is used and the distance is similar, the transportation cost is no affected by the origin country. Table 16 presents the costs if estimation is done using different way

Table 16. Outbound costs for electrical parts and valves if transported at the same time (Metso. 2024h; Metso, 2024j).

Parts	**From**	**To**		
		USA EUR	Europe EUR	China EUR
Electrical parts	Finland	660,00	1400,00	360,00
	China	740,00	470,00	NA
Valves	Finland	660,00	1400,00	360,00
	China	740,00	470,00	NA

*NA means not available

Other way to estimate the cost for outbound transportation is to assume that all the valves and electrical parts from Finland going to USA, Europe and China are transported at the same time and same for parts sourced from China according to Table 16. Costs from China to China were not estimated because parts come from different suppliers and outbound costs can not be estimated because the parts are not exported. If these costs are compared to

transportation cost for individual parts, it can be stated that there is no difference between the transportation costs. This can be due to fact that most parts are transported via ocean and there might be minimum weight cost till certain weight is crossed. Most of parts are light weighted which explains this. Also, exclusion of packaging weight affects to the estimated cost because usually the package is taken into account.

On average, outbound costs for electrical parts cost to USA is 690 euros, to Central Europe 1080 euros and to China 230 euros. For valves outbound cost to USA are 700 euros, to Central Europe 930 euros and to China 180 euros. (Metso, 2024j.) The differences are explained by few key factors. The difference between USA and Europe comes mainly from transportation method. To USA the parts are shipped and to Europe transported via road. The major difference in transport cost to China originates from the supplying country that is China and decreases the cost dramatically.

Sourcing valves globally from Finland and China to USA including part cost and transportation is on average 1250 euros, to Central Europe 1490 euros. Using global sourcing to China, the average cost is about halved in comparison at 680 euros. (Metso, 2024j.) If valves are sourced locally in China, the cost decreases even more to 590 euros. This is explained mostly by supplying location that is China and if the all the valves are sourced from China, lowest price is achieved.

Sourcing electrical parts globally from Finland and China to USA, the average cost is 980 euros, to Central Europe 1400 euros and to China using global sourcing 650 euros. If electrical parts are sourced locally in China, the cost on average is 290 euros. (Metso, 2024j.) The main reason for the difference in global and local sourcing in China is that decreased transportation cost overweighs higher part cost.

5.2 Environmental

Metso has stated that most of their environmental impacts come from energy consumption, water consumption, waste generation and atmospheric emissions. These impacts are mainly related to activities in service and research centres, laboratories and manufacturing sites. External activities such as procurement and logistics are followed so indirect impacts can be reduced. They also pay attention to biodiversity aspects as biodiversity loss can affect

Metso's value chain. The biodiversity footprint mainly consists of customer's operations and Metso has various options for customer to utilize, for example process water treatment solutions and (Metso, 2024k.)

Metso has ambitious emission reduction targets. They aim to be net zero by 2030 and by 2025 they aim to reduce their emissions by 20%. Water consumption is aimed to be reduced by 15 % per employee in areas which are water scarce. By 2030, amount of landfilled waste is targeted to be reduced by 90%. These targets are planned to be achieved by increasing the usage of renewable energy, improve own energy production for example with solar systems and ground heat, utilizing processed overflow waters and using condensation water for example for plant watering and cleaning. (Metso, 2024k.)

Scope 3 emissions are aimed to reduce by planet positive portfolio, optimizing transportation methods, supply chain transparency, using carbon free logistics, using models which are sustainability-focused, new technologies for downstream solutions and products which have carbon free value chain. Scope 2 emissions are reduced by using green district heat and renewable energy, carbon neutral sites, energy attribute certificates. Scope 1 emissions are reduced by improving process efficiency and maintaining equipment and facilities, using biofuels and low carbon fuels, generating renewables, electrification, surplus energy production on sites and implementing new technologies. Scope 1 emissions need emission offsetting. It has been planned that scope 1 and 2 would achieve net zero state by 2030 whereas scope 3 should meet the net zero target by 2050. (Metso, 2024k.)

From warehouse point of view, this report is giving overview of general data regarding warehouses located in Finland and in China. Warehouse in Finland the energy need is covered by using wind energy. The annual need for energy was approximately 240 000 kWh per year. In China energy is produced from coal and need for energy was 54 000 kWh. Energy is not produced by Metso. Share of waste in Finland and China are presented in Figure 12 A and B.

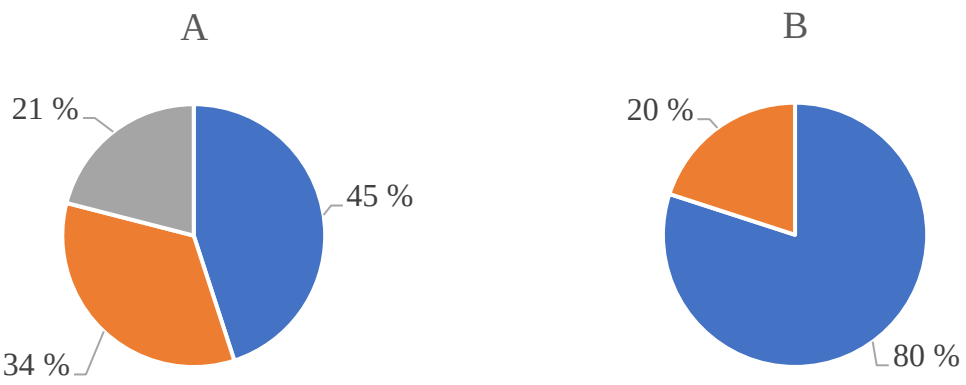

Figure 12. Share of waste in China (A) and Finland (B) (Metso, 2024l).

In Finland, most waste is wood, accounting approximately 80 % of all waste. In addition, carton and metal waste is generated and they account for 20 %. Total amount of waste was 350 tons. In China most waste is also wood, accounting for 45 %, metal waste accounts for 34 % and last 21 % come from carton and hazardous waste. Total amount of waste was 10 tons. Warehouses use fuel for forklift, and used fuel in Finland and China is diesel. Diesel usage in Finland was around 19 000 litres per year and in China 23 000 litres per year. These numbers are from year 2023. (Metso, 2024l.) Currently over 90 % of used packaging materials in Finland are recyclable and in China same number is over 80% (Metso, 2024m). Emissions from warehousing are not currently calculated and the calculation method is in work (Senior manager, logistics sustainability, 2024). Therefore, warehousing emissions are not included in this assessment.

Emissions from transportation are presented as estimations from year 2023 using the warehouse locations and locations of the suppliers because exact emissions from transporting certain parts can not be estimated from the data. It is worth of noticing that these emissions are summarized from existing data from chosen location to another, direct locations are not presented. These emissions cover all transportation taking place in this location related to Metso’s business. Presented emissions include emission from all movement between locations, for example delivering products related to other technologies than parts used in this research. Inbound emissions in China and Finland are presented in Figure 13.

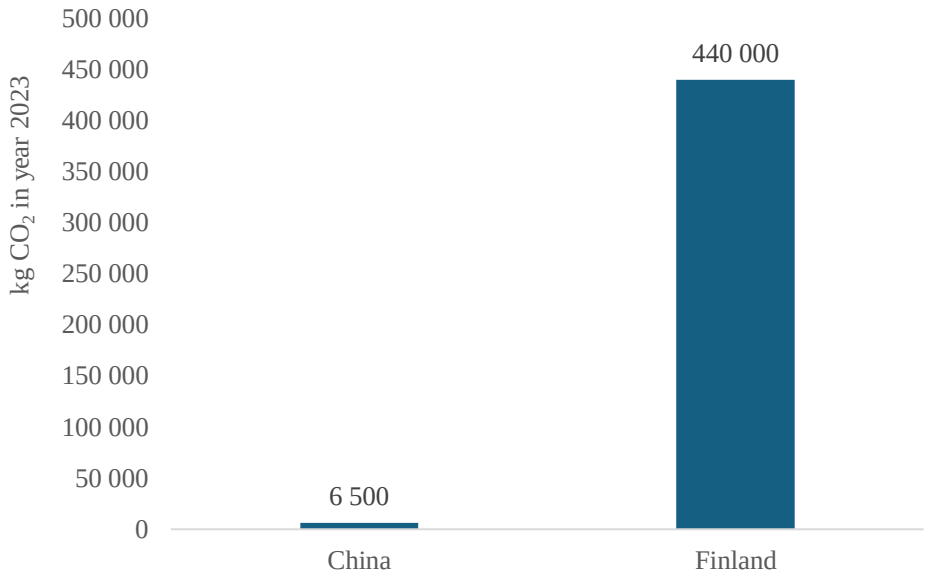

Figure 13. Inbound emissions from China and Finland (Metso, 2024n).

Inbounds in China cover approximately 6500 kg CO_2 emissions and same in Finland is 440 000 kg CO_2. There is notable difference between the inbound emissions. The main reasons for this difference are the number of transportations in lower than in Finland and the transportation mode. In addition, the size and weight of the transported parts and products affect to the amount of emissions. Outbound emissions from Finland to USA, Central Europe and China compared to outbound emissions from China to USA and Central Europe are presented in Figure 14.

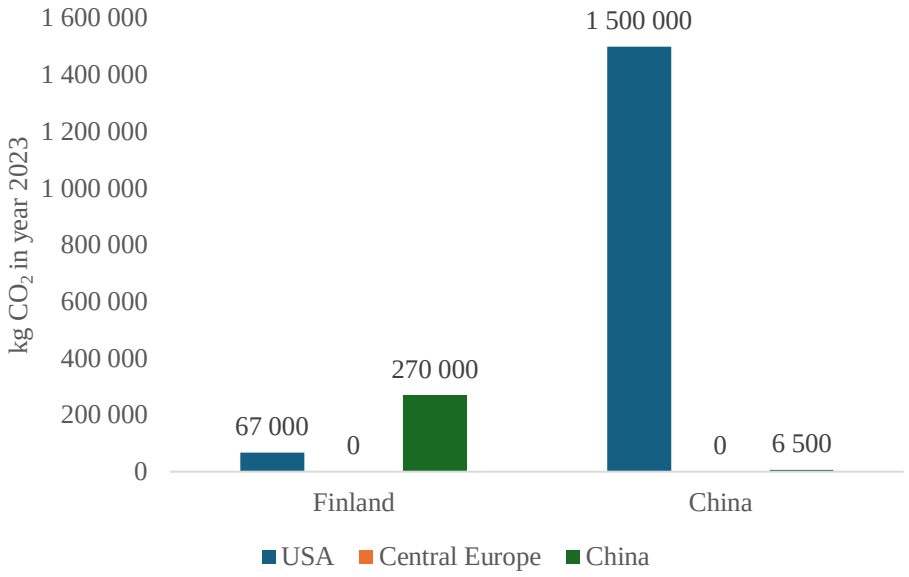

Figure 14. Outbound emissions from China and Finland (Metso, 2024n).

Outbound emissions from Finland to selected location in USA emissions were 67 000 kg CO_2, to China 270 000 kg CO_2 and to Central Europe 0 kg CO_2. Outbound emissions from China to Central Europe are 0 kg CO_2 and to USA 1 500 000 kg CO_2 in 2023. (Metso, 2024n.) Reason for the 0 kg CO_2 emissions from logistics to Central Europe is that data is for year 2023 and the data did not include emission to the warehouse in Central Europe. As can be seen from the figure, emissions from China to USA are significantly higher than to other locations either from China or Finland. These differences can be explained with same reasons as the difference in the inbound emissions. Chosen transportation mode, transportation distances, number of transportation and size and weight of products and goods are aspects which affect to the amount of emissions. Based on the results, it would be ideal to focus on decreasing the inbound emissions in Finland because it is most impactful. Data acquired local sourcing would be preferable on environmental aspects because it eliminates emissions coming from outbound traffic.

6 Discussion

Global sourcing is one of the strategies implemented in modern economy companies. Companies utilize these strategies to ensure their competitiveness but at the same time they expose themselves to greater risks. Global sourcing can for example cause risk for longer lead times and in that way the uncertainty of delivery increases. (Trkman and McCormack, 2009; Colicchia, Dallari, and Melacini, 2010, according to Chan and Lin, 2019, 298.) On the other hand, global sourcing offers lower prices, but the downsides are the stability issues regarding supply chains. The total cost of global sourcing depends on several factors, for example characteristics of products, demand and supply. (Levy, 1995; Lowson, 2002; Nassimbeni, 2006, according to Holweg, Hong and Reichhart, 2011, 333.)

There are three main challenges which have been recognized especially when sourcing from China. One challenge is relationship with supplier due cultural aspects. It often requires time and effort to accomplish relationship with Chinese people. Although good relations are important, there is a difference between good relations and corrupt behaviour (Li et al., 2001; Mavondo and Rodrigo, 2001; Gold et al., 2002; Eberhardt et al., 2004; Millington et al., 2005; Wilkinson et al., 2005; Bergman, 2006; Salmi, 2006, according to Gunasekaran, Platts, Sharif and Song, 2010, 321.) Corruption is existing issue in China (Murphy et al., 1993; Gupta, 2005; Chen et al., 2011, according to Li, Kim and Tarzia, 2018, 112). Second challenge is quality. China suffers from fluctuations in quality, low performance of delivery, expertise of technology, quality of raw materials, low capacity of machinery and insufficient equipment inspections. These aspects might make sourcing from China unattractive option. Third challenge is that logistics in China is poor although there have been improvements (Eberhardt, 2004; Goh and Ling, 2004; Ting; 2004, according to Gunasekaran et al., 2010, 321.)

Tactical Sourcing Manager was interviewed to get more information about practicalities regarding sourcing in Metso. Interview questions are presented in Appendix 1. Supplier selection in Metso is mainly based on preferred suppliers which are set for each business lines. In addition, earlier history can be used as a reference when selecting supplier for each case. Sometimes also customer's opinion can affect to the selection between local and global sourcing. Example of this kind of situation is that customer does not want parts to be sourced

from certain countries. Local sourcing is preferred when shorter lead times are looked for and sustainability targets are taken into account. (Tactical Sourcing Manager, 2024.)

Internal information about logistics operation in Metso was got by interviewing Senior manager of logistics. Interview questions can be found form Appendix 2. Logistics in Metso are handled by logistics team who are responsible for inbounds and outbounds for selected locations. The main responsibility is to take care of the transportation bookings of spare parts to the determined locations. (Senior Manager Logistics, 2024). Inbound and outbound logistics are core activities when it comes to logistics. Logistics also take care of control of transportation and inventory (Chan, Chiu and Choi, 2016, 1.)

The selection of transportation mode in Metso is based on the delivery date which is requested by customer. In sales order, promised delivery date is provided and together with delivery priorities the proper transportation mode is determined. Also, vendors and routings can be factors which affect to the delivery mode together with availability of delivered parts. In addition, sustainability aspects have increased their importance in logistical operations. Transportation actions are provided by external partner. Warehousing which is also related to the logistical operations is partially managed by external partner but also partially managed by Metso, depending on the purpose of the facility. (Senior Manager Logistics, 2024).

Geography causes challenges for example regarding responsiveness, delivery, quality, cost and innovations. Geography can be divided into physical and human geography. Physical geography includes natural phenomena, spatial aspects and distances. Human geography is more related to interactions between cultures, environments and communities. Geography is important factor because it affects to the designing of the delivery network and selection of correct transportation mode. (Novak and Choi, 2016; Kumar et al., 2020, according to Choi, Narayanan, Novak, Olhager, Sheu and Wiengarten, 2021, 202-203.) Geography is taken into consideration in Metso's operations regarding selection of transportation mode and routes.

There are several risks which can be related to the logistical operations. Main risk come from accidents happening all over the world. These kinds of risks can be due for example from war between Russia and Ukraine, attacks on Red Sea and strikes. Cyber risks haven't been brought to attention. (Senior Manager Logistics, 2024). These kinds of global disruptions can be good opportunity to improve trust between shippers and third party-logistics (TPL)

(Lennanem 2019, according to Choi, Naranyanan, Novak, Olhager, Sheu and Wiengarten, 2021, 204).

From social point of view health, well-being and safety of employees, partners, and customers are important in Metso. Metso has target of zero harm, and it is continuously trying to improve the safety of all parties which are related to Metso's operations. Metso does have fatality prevention program which has started in 2022, and its purpose is to prevent injuries which are severe and fatal accidents. Based on that program, Metso formed Life Saving Rules which includes ten directives. Directives presents the ten high risk situations: chemicals, confines spaces, forklifts, hand tools, lifting, machine safety, road travel, working at heights and working at customer sites. (Metso, 2024o.)

In addition to health, safety and well-being, Metso is committed to working environment where diversity and inclusion are part of the culture. To promote the well-being of employees, Metso offers various trainings and webinars regarding physical and mental health on a global level, but concrete actions are made in a local level. National and international law, human rights and regulations are respected in Metso. Metso is committed to operate according to the Ten Principles of the United Nations Global Compact and the International Labour Organization's Declaration of Fundamental Principles and Rights at Work, the United Nations Universal Declaration of Human Rights, and the United Nations Guiding Principles on Business and Human Rights. (Metso, 2024p.)

In Metso, Code of Conduct and other policy frameworks are implemented and all business decisions and actions must be ethically and legally according to those. In Code of Conduct the key principles are presented and they guide the daily work. All employees are expected to follow it in every action of their work, whether it is business situation or other transaction. (Metso, 2024q.) Code of conduct consists of 5 main areas which are people, business conduct, company assets, sustainability and speak up (Metso, 2024r).

To get more information regarding supplier sustainability supplier quality and development director was interviewed. Interview questions are presented in Appendix 3. Supplier sustainability is based on Metso's code of conduct which is signed in the beginning of the business relationship and monitored through it. Signing of the code of conduct is required for all the suppliers. Health and safety and actions related to climate change can be highlighted from the code of conduct to be important but all aspects of the code of conduct

are equally important. All suppliers are expected to meet the same requirements and location, or nationality of supplier does not affect that. Cultural differences are acknowledged within the company due various nationalities among employees. (Director, supplier quality and development, 2024.)

Also, suppliers have their own code of conduct. It is base for the new business relationship. (Metso, 2024l.) Metso's supplier code of conduct is based on Metso code of conduct and United Nations Global Compact Initiative. Supplier code of conduct includes variety of requirements for supplier related to sustainability, for example responsible business practices, child and forced labour, health and safety. Metso monitors the suppliers code of conduct for example by auditing. Although this research excludes the information related to the sub-suppliers it is mentioned in the supplier code of conduct that Metso's suppliers must take care that suppliers' suppliers are meeting the same requirements as mentioned in Metso code of conduct (or similar). Supplier also need to monitor their sub-suppliers and share relevant information to Metso. (Metso, 2024s, 2-7.)

Metso has various corporate social responsibility (CSR) programs, and it has committed to take accountability of social aspects where it operates. These programs are managed and sponsored by local organizations. (Metso, 2024t.) For sustainability related information, Senior manager of Sustainability was interviewed. Interview question can be found from Appendix 4. Metso does not monitor customer's sustainability. In general, role of social aspects is increasing, and it is more and more taken into account in supply chain operations. Supply chain become more complex and longer due globalization which increases the importance of social aspects. (Senior Manager, Sustainability, 2024).

In simply put, social sustainability in supply chain context is focused on health and safety and ensuring human rights by including code of conduct. Companies also monitor their supplier and their actions regarding sustainability by auditing and inspections. This kind of monitoring can be targeted also towards customers. In social sustainability it can be thought that some practices are more advanced than others. These advanced practices produce new products and at the same time producing benefits to community and stakeholders. Other way to provide benefits is to modify the supply chains. (Pagell and Wu, 2009; Spence and Bourlakis, 2009; Awaysheh and Klassen, 2010; Ashby et al., 2012; Klassen and Vereecke, 2012; MacCarthy and Jayarathne, 2012; Ayuso et al., 2013; Huq et al., 2014, according to Claudy, Marshall, McCarthy and McGrath, 2015, 437-438.)

Specifically, regarding sustainability supply chain related targets are mainly reducing emissions from logistical operation and get suppliers to follow scientific based targets. Main issues related to supply chain in Metso are emissions to air but also biodiversity is considered. As mentioned, Metso has net zero goal for year 2030 and this is achieved by emission reduction and not by compensating. Metso has implemented circular practices in their supply chains, mainly reverse logistics so that old and used spare parts can be recycled and used again. (Senior Manager, Sustainability, 2024.)

Senior Manager of logistic sustainability was interviewed to get information about sustainable logistics operations in Metso and to get data about emissions related to the logistics. Interview questions are presented in Appendix 5. Most significant impacts related to logistics are emission from transportation and packaging. Packaging waste is aimed to be reduced by using packages which are durable from the vendor to customer. Packaging materials are also reused if possible. Circular practices are implemented in supply activities in forms of repairing and refurbishment, but circularity in Metso's operations is developing area. (Senior Manager, logistic sustainability, 2024.)

Logistical operations related to supply chains can create positive socio-economic effects but on the other hand negative effects can occur. Due logistical operations, infrastructures are constructed, wealth rate increases, new jobs are created, and hunger, poverty and crime rates are lowered. Negative effects are more related to the environment and society. Logistics can be heavily dependent on fossil fuels and usage of non-renewable resources, increase the amount of different pollutions and effect negatively to health and safety (Abbasi and Nilsson, 2016, 273-274.)

To get more information regarding the supply chains and practicalities regarding them in Metso Senior Manager, Sustainability was interviewed. Interview answers are presented in Appendix 6. Metso's supply chains include various organization involved from the supplier's partners to customer's partners. There are also many internal organizations which are included. Several organizations are also included in the managing supply chains. (Senior Manager, Supply Chain Optimization, 2024.)

Metso's supply chains face different challenges which some of them are more related to the logistics and some for-example lack of proper information and knowledge. Massive amounts of data create its own challenges. Supply security and resilience can be maintained with

proper information and knowledge, well established communication and collaboration, agile processes and proactiveness. Lack of collaboration and communication can be seen as one of the weaknesses of supply chains. One major strength is that Metso educates its employees. (Senior Manager, Supply Chain Optimization, 2024.)

Supply chains do face external disturbances such as pandemics and wars which do affect to the supplying activities. They cause instability, logistical hazards, lack of raw materials and increasing amount of stocking which is due so-called bull whip effect. Metso does cope with these changes by learning from the earlier cases, reacting to risks and improving the overall knowledge. (Senior Manager, Supply Chain Optimization, 2024.) Bull whip effect is a term related to supply chains which refers to situation where small change in demand causes fluctuations in orders received by upstream supplier. Bull whip effect can be caused one or combination of for example low inventory, high demand, high-capacity utilization, long lead times and high costs (Garg and Singh, 2015, 994). Bull whip effect can be reduced for example by lead time reduction and increased transparency of information. (Forrester 1958 and 1961; Lee et al. 1997; Wang and Disney, 2016; Lin et al., 2017, according to Lin, Liu, Yang and Zhou, 2021, 1.)

Resilience of the company is seen to be dependent on the ability to response to the unexpected disruption by the customer and suppliers (Croxton, Fixel and Pettit, 2019, 59). Because of the complexity of current economic system which is due the interaction between producers and consumers all over the globe increases the vulnerability. Events such as natural disasters, financial crisis, terrorism and other conflicts can affect negatively to the supply chains globally. For example, events related to the climate change can affect to the efficiency and resilience of economic systems. (Albrow, 1996; Castells, 1996; Regmi, 2001; Krausmann, 2004; Yamano et al., 2007; Barker and Santos, 2010, according to Andreoni and Miola, 2015, 6-7.) Supply chain robustness is also seen important because it is linked to supply chain reliability (Snyder and Daskin, 2005; Peng et al., 2011, according to Fahimnia, Jabbarzadeh and Sarkis, 2018, 129).

7 Conclusions

The goal of this work was to study supply chains and their sustainability aspects. The empirical was conducted to Metso. Empirical part was focused on exploring the effects of global and local sourcing from sustainability point of view and investigate if the sourcing logic be updated based on the results. There is external pressure for companies to pay more attention to their sustainability which makes the topic relevant for research from the company point to view.

Majority of economic expenses come from the transportation for the parts in this research. To USA is it more ideal to source from Finland because part and transportation costs are lower and lead time is shorter, overall, supplying from Finland can be almost 16 % cheaper. To Central Europe the sourcing is more ideal to be done from Finland if selection criteria is part cost and lead time. Although part cost and lead time are lower compared to China based sourcing, transportation costs from Finland are almost three times higher than from China. If transportation costs are included, the overall cost for parts delivered are lowest from China with 45 % savings. To China, local sourcing is ideal from the lead time and transportation cost point of view, with 40 % savings compared to sourcing from Finland.

From the social point of view literature presents that cultural differences between business in China and other countries can cause challenges. Metso as a company requires same actions from all suppliers apart from the location and nationality of suppliers. The benefit of multinational company is that there are employees from different countries which makes the collaboration and communication easier despite of the cultural differences. Although there are some challenges related to the Chinese vendors presented in literature, Metso requires all suppliers to sign same requirements on the supplier code of conduct and location, or nationality of the supplier does not affect to that. From Metso point of view social sustainability is well taken into account and it is important for the company that social aspects of the business actions are known and considered. Metso monitors their suppliers that they meet the requirements set in the supplier code of conduct.

From environmental point of view warehouse in Finland can be considered more sustainable than Chinese warehouse. Although Finnish warehouse uses more energy, it is generated from renewable energy resources unlike in China. In Finland also less fuel is used in warehouse

operations than in China. To improve the sustainability of warehouses it would be beneficial to conduct comprehensive research about the environmental impacts of these warehouses. From transportation point of view inbounds in Finland are higher in emission than in China. It is worth of noticing that higher inbound emissions can be due higher number of transportations occurring in Finland. If the company wants to take actions to reduce emissions form transportation, based on the research, the most impactful target is inbound transportation in Finland. To USA emissions from Finland are lower than from China and to Central Europe. Local sourcing is preferred in China based on transportation emissions because they are lower than compared to if parts are transported from Finland to China.

Both simple and complex supply chains were studied. Other supply chains do represent complex or medium complex supply chains but local sourcing in China is considered to be simple. Resilience and vulnerability are seen important in business because by taking into account different risks, better resilience can be ensured. Reducing complexity of supply chains in global company strengthens resilience. Another option is to widen the supplier base. Company needs to ensure good collaboration and communication between teams inside the company but also with other stakeholders such as customers and suppliers which improves the resilience alongside with information transparency and traceability.

When taking a look at the results it is worth of noticing that data has impact to the results. The overall results can vary if the sample size is wider, and more aspects could be included. In addition, the interpretation of the data can vary depending on the point of view. Data itself is primary data from Metso, but the origin of that data can not be traced with the research access level. Transparency of data would be important from the reliability point of view. Transparency and accuracy of the data is the weakness of this research. Currently the information regarding the supply chains is shattered in a sense that the data managed by individual teams and gathered from the point of view of these teams. This in some way explains the lack of comprehensive research regarding supply chains in Metso. It is notable that this data and results can not be generalized for all countries and all parts. On the other hand, using primary data can be seen as a strength because it is company related data and reflects the situation going on in the company.

Sustainability of Metso's supply chains can be studied in future in wider scope. This future research would require the results to be used only in internal purposes. In this research some of the relevant information was required to be excluded because of the confidentiality. That

affects to the results of this research by simplifying the outcome. By including this information, deeper understanding of the sustainability could be achieved and the overall knowledge about the supply chains would be improved. Currently this kind of comprehensive research does not exist inside the company. Supply chains are more studied and analysed internally within different teams which may cause communication problems and lacking overall knowledge. Understanding the supply chains and the effects of global and local sourcing can enable updates to sourcing logic and shape supply chains to be more sustainable.

8 Summary

The goal of this thesis was to investigate the different aspects of sustainable supply chains and their management in general. In addition, the effects of global and local sourcing of spare parts in Metso from the sustainability point of view in terms of economic, social and environmental aspects were studied. This research tried to find the differences between sourcing from Finland and China and explore the options how sourcing logic could be updated based on the results.

Supply chains in general are routes for companies to provide goods to their customers. Supply chains consist of several different actors which might simultaneously be part of various supply chains. Well established collaboration between these actors ensures the efficient functionality of supply chain. Supply chains can be simple but often they tend to get complex when there are many different global actors in the mix. Global sourcing offers wider supplier base, but it can also increase different supplying risks.

Sustainability is complex and wide concept when it comes to supply chains. Sustainable supply chain includes all dimensions of sustainability including economic, social and environmental aspects. All dimensions do have their specific characteristic and focus areas on sustainable supply chain management. Sustainability of actors participating to the supply chain determines the sustainability of the whole supply chain. This highlights the importance of sustainability of individual actors.

Main findings based on research was that there are certain differences between sourcing from China and Finland. Sourcing from Finland provides lower part cost, lower transportation costs, shorter lead times and lower emissions if the end customer is in USA. From China the parts are more expensive and lead times slightly longer to Europe, but transportation costs are lower to Central Europe and China. Most significant difference was in local sourcing in China where total price of the parts was almost half when comparing to other supply location and end customer countries. From resilience point of view company should be attention to well established collaboration and communication with both internal and external partners to improve overall resilience of supply chains.

In future, role of local sourcing could be highlighted more in cases where it is possible based on the benefits related to the shorter lead times and lower transportation costs and distances. Because of complexity of sustainability, sustainable supply chains do include more information and aspects than this research could include because of confidentiality. Same research could be done only for internal use widening the scope which would result more detailed results and deepen the understanding the sustainability of Metso's supply chains.

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Appendix 1. Interview questions regarding sourcing

Interview questions for Tactical Sourcing Manager

What is the supplier selection based on?

When is local sourcing preferred over global sourcing?

How are local and global sourcing defined?

Appendix 2. Interview questions regarding logistics

Interview questions for Senior Manager, Tactical Sourcing Manager

What is the scope of logistics team?

How is the transportation mode selected and what is the selection based on?

What mode of transportation is used and what are the distances?

How much does the transportation cost per selected item?

How much does the packaging cost?

How much does the warehousing costs?

Is warehousing bought from external party?

Is logistics bought from external service provider?

What kind risk there are related to the logistics operations?

Appendix 3. Interview questions regarding sustainable supplier

Interview questions for Director, Supplier Quality & Development

How Metso ensures the sustainability of suppliers?

What kind of sustainability related actions does Metso requires or expects from their suppliers?

What kind of sustainability targets Metso has regarding supply chains?

Are there challenges related to vendors which are in different locations?

Appendix 4. Interview questions regarding sustainability

Interview questions for Senior Manager, Sustainability

How Metso ensures sustainability of suppliers?

What kind of sustainability goals does Metso have regarding their supply chains?

What kind of environmental aspects are taken into account?

Metso has the net zero goal for year 2030, how the emissions are compensated regarding supply chains and what are the actions needed?

What are the main sustainability or environmental issues which are caused by supplying activities?

Are circular practices implemented in supply chain activities?

Appendix 5. Interview questions regarding sustainable logistics

Interview questions for Senior Manager, Logistics Sustainability

What are the main sustainability or environmental issues which are caused by supplying activities?

Are circular practices implemented in supply chain activities?

Appendix 6. Interview questions regarding supply chain management

Interview questions for Senior Manager, Supply Chain Optimization.

What does you and your team do?

How supply chains are managed and determined?

Who are the main actors in the supply chains in general?

What are main challenges regarding supplying activities?

What aspects might affect to the supply security/resilience and how it is ensured

Is there weaknesses in the Metso's supply chains?

What are the strengths of Metso's supply chains?

How has the current world situation affected to the supply chains?

How does Metso's supply chains cope with changes, for example COVID19 or such?

How cyber resilience is ensured?