INVESTIGATION OF SUSTAINABLE SUPPLY CHAIN IMPROVEMENT BY THE REDUCED USE OF SUBSTANCES OF VERY HIGH CONCERN IN THE GLOBAL TECHNOLOGY SECTOR COMPANY

Lappeenranta–Lahti University of Technology LUT

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Examiner(s): Professor Katrina Lintukangas, D.Sc (Econ. & Bus. Adm)

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ABSTRACT

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This master's thesis examines the barriers, benefits and overall impact on a company's operations when it seeks to reduce substances of very high concern (SVHCs) as per the European Union's REACH Regulation. The ultimate goal is a sustainable supply chain, which is an expectation of both stakeholders and regulators for companies.

The main data of the case study consists of conducted interviews, which are analysed using content analysis methods. The most common barriers for companies in reducing substances of very high concern are the lack of internal resources and strategy, rising total costs and the lack of SVHC-free components in the market. The main benefits that companies can achieve from reducing SVHCs are regulatory compliance, improved company reputation and stakeholder satisfaction, and sustainability related competitive advantages, which can lead to long-term economic benefits and make the company a preferred business partner.

Reducing substances of very high concern has a comprehensive impact on the company's operations, but the purchasing and supply management and research and development in particular play a key role in this process, which requires close and proactive cross-functional collaboration to be successful. Key sustainability goals such as reducing substances of very high concern must be linked to the company's strategies and business model, and combined with other increasing sustainability obligations, that the company can find a balance between maximizing sustainability improvement and remaining cost competitive.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

LUT-kauppakorkeakoulu

Supply Management - Maisteriohjelma

Niklas Kinnunen

Tutkimus vastuullisen toimitusketjun parantamisesta erityistä huolta aiheuttavia aineita vähentämällä globaalissa teknologiasektorin yrityksessä

Kauppatieteiden pro gradu -tutkielma

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Tämä pro gradu -tutkielma tutkii esteitä, hyötyjä ja kokonaisvaltaista vaikutusta yrityksen toimintoihin, kun se pyrkii vähentämän erityistä huolta aiheuttavia aineita (SVHCs) Euroopan Unionin REACH-asetuksen mukaisesti. Lopullisena tavoitteena on vastuullinen toimitusketju, mikä on sekä sidosryhmien että lainsäätäjien odotusarvo yrityksille.

Case-tutkimuksen keskeisin aineisto muodostuu toteutetuista haastatteluista, joita analysoidaan sisällönanalyysin keinoilla. Yleisimpiä esteitä yrityksille liittyen erityistä huolta aiheuttavien aineiden vähentämiseen ovat yrityksen sisäisten resurssien sekä strategian puute, nousevat kokonaiskustannukset ja SVHC-vapaiden komponenttien puute markkinoilla. Keskeisimmät edut mitä yritykset voivat saavuttaa SVHC-aineiden vähentämisestä ovat lainsäädännön noudattaminen, parantunut yrityksen maine sekä sidosryhmien tyytyväisyys ja vastuullisuuden aiheuttamat kilpailuedut, jotka voivat johtaa pitkän aikavälin taloudellisiin etuihin ja tehdä yrityksestä ensisijaisen yhteistyökumppanin.

Erityistä huolta aiheuttavien aineiden vähentäminen vaikuttaa kokonaisvaltaisesti koko yrityksen toimintoihin, mutta erityisesti osto- ja hankintaosasto sekä tuotekehitys ovat keskeisessä roolissa tässä prosessissa, joka vaatii tiivistä ja proaktiivista osastojen välistä yhteistyötä onnistukseen. Keskeiset vastuullisuustavoitteet kuten erityistä huolta olevien aineiden vähentäminen täytyy liittää yrityksen strategioihin ja liiketoimintamalliin, ja yhdistää muiden lisääntyvien vastuullisuusvelvoitteiden kanssa, jotta yritys voi löytää tasapainon parannetun vastuullisuuden maksimoinnin ja kustannuskilpailukyvyn säilyttämisen väliltä.

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A Declaration of AI usage:

No AI tools were used in the thesis.

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1 INTRODUCTION

This thesis aims to investigate the overall impact and influence on the case company and especially to the purchasing and supply management (PSM) regarding the need to reduce the use of Substances of Very High Concern (SVHCs). It focuses on the barriers and problems the PSM and the company in overall may face when trying to reduce the use of SVHCs containing items and components, which they are supplying currently. In addition, the focus is on benefits and new value, which the company can gain by reducing the use of SVHCs and moving towards more sustainable supply chain (SSC) and overall business operations.

Sustainability has become one of the grand challenges and aims for companies to achieve during the last decade. Stakeholders are demanding companies to improve their sustainability in all areas and buying firms are held accountable for sustainability misconduct even if the violation happens far beyond their direct control in the supply chain. (Meinlschmidt, Schleper & Foerstl, 2018) Supply chain sustainability should be seen as an iceberg, where only the top is visible, but the biggest issues often happen upstream in the supply chain, beyond direct control of the buying firm (Meinlschmidt et al., 2018). For this reason, the companies must pay attention to sustainability improvements and always aim for increasing transparency of the sustainability-related issues in their supply chains. Moral obligation to act in right way, which is being expected by the customers and other stakeholders is one of the most important pressuring incentives for companies to operate sustainably (Montiel, 2008).

Sustainability regulations and reporting requirements are also becoming increasingly stringent. Since July 2021, companies have been obliged to report the use of SVHCs to the *Substances of Concern In articles as such or in complex objects (Products)* SCIP database of the European Chemicals Agency (ECHA) in all articles containing any SVHC over 0,1 % per article weight (Ministry of Social Affairs and Health, 2021) The demand for reporting the SVHCs and increasing regulations related to these substances are for the companies operating in the European Union (EU) market (ECHA, 2024a) and it is visible that the EU has taken increasing focus on overall sustainability improvement and is wanting to show example to other market regions in the world.

The current speed of development in sustainability theme shows that companies must take things seriously and focus on these issues. Not only the laws and regulations are getting more strict and demanding companies to pay attention to these things, but also the stakeholders are expecting that companies must do the right thing, which is to be sustainable.

SVHCs are important sustainability related topic in the EU region and gaining more prominence. The EU is trying to foster the reduction of these harmful substances and the requirement for transparency is used as a regulation tool. (Schenten, Brenig, Führ & Bizer, 2020) However, what is currently bit paradoxical is that each EU member state is responsible for the enforcement of the regulations and the ECHA is not taking responsibility for it. National authorities can issue fines and other penalties based on own judicial system if regulations are not met. (ECHA, 2024c) Due to this, the enforcement is not very clear at the moment, which can be related to general high cost of meeting SVHCs regulations and potential negative impact they can have to the EU as a business region and the companies operating inside EU, if the rival business regions are not enforcing similar regulations. Despite this, companies must understand that both the regulations and enforcement are likely to get stricter in the future, which is why companies must act now to get prepared for the future. Already now, increasing transparency and demand for reporting makes the issue crucial for companies since everything id visible and it is likely that in the future stakeholders avoid doing business or collaboration with the companies who are using these harmful substances and not trying to systematically reduce them.

1.1 Research gap and justification

SSC and improving the overall sustainability of the companies has attracted attention from many scholars in recent years, while the big part of that academic focus has been on climate change impact, carbon emissions and global warming (Dubey, Gunasekaran & Papadopoulos, 2017). Reefke and Sundaram (2017) suggested regarding SSC studies that more focus should be paid on SSC linkages between economic, social and environmental objectives. They suggested that important topics to study in the future would be for example supply chain sustainability implementation costs, justification for sustainability improvement and barriers to different supply chain sustainability implementation including time, costs and resources (Reefke & Sundaram, 2017). These suggestions are very close to

the topic of this research, when the aim is to study barriers including the costs for SSC improvement by reducing the SVHCs items, but also justification for reducing the SVHCs due to potential benefits from it, in addition to what the regulations demand.

Limited academic research material can be found from SVHCs and supply chain sustainability improvement. Schenten et al. (2020) noted that firstly a problem is that very few companies are submitting SVHCs information to the ECHA's SCIP database and there are problems in meeting the other reporting obligations also. Since 2021, the SCIP database declaration has been mandatory for all SVHCs containing items if being over 0,1 % of consumption from items' weight (ECHA, 2024a), but it can be still estimated that there are issues with this regulation, which increases the need for additional research. Klaschka (2017) suggested that companies must start work to eliminate SVHCs from their products and components, because it makes them prepared for future restrictions and save the costs and resources. However, to achieve this, it is important to study the potential barriers and benefits of this process. The SVHCs elimination process cannot be started and done blindfolded.

Klaschka (2017) also noted that consumers need more information regarding the SVHCs, and they deserve to know about them, since it increases the transparency and pressure to substitute SVHCs items with SVHC-free items. Last few years the development has gone fast to this direction, which increases the need for investigation that studies the impact to supply chain management (SCM) when the SVHCs containing items are substituted. Including what barriers and benefits the companies may face when aiming for this. Coria, Kristiansson and Gustavsson (2022) investigated how the need to reduce use of hazardous SVHCs items and the economic interests are often conflicting, which has also impacted the regulations regarding the SVHCs. This study also aims to add more research material to this issue when the attempt is to study how purchasing costs may change if SVHCs components are replaced with the SVHC-free components.

Recent research on SVHCs has primarily focused on their identification and characterization. Wassenaara, Rorijea, Janssen, Peijnenburg and Vijver (2019) studied how to identify different SVHCs by their chemical similarity, which was very useful study to recognize these substances before as strict regulations and demands as these days were present. However, currently there is already an extensive list of SVHCs available, which is updated by the ECHA (ECHA, 2024b), and from there companies can find the substances, which they should avoid and reduce, at least if the companies have the information on what

their components include. A clearer research gap can be identified on related to the actual operational process of PSM and the whole company, when ultimately trying to reduce the use of SVHCs. Biggi (2024) suggested that future research regarding SVHCs should investigate the long-term effects of regulations to the firm performance and conduct firm-level analysis to understand better how SVHCs regulations influence the firm's performance, innovation, competitiveness and short-term financial aspects. This thesis aims to find answers to many of these questions, which is why it is extremely beneficial to study the impacts to SCM and what barriers but also benefits the companies may face when reducing the use of SVHCs.

1.2 Research questions

The objective of this study is to explore the practical implications of reducing the use SVHCs in a global technology sector manufacturing company, focusing on the barriers and potential benefits. The company has several products which include SVHCs since these dangerous substances are for instance very common in many electronic components, which highlights the urgent need to start reducing the use of these substances gradually. The main aim for this process is to improve the overall sustainability of the company and move towards the SSC. The regulations and laws are also getting stricter all the time, which brings external pressure to comply with the legislation. In addition, the moral obligation to act sustainably is a strong incentive and something what the stakeholders are considering should be the normal and expectation, not a positive bonus.

Therefore, the main research question of this paper is:

1. How does the reduction of SVHCs affect purchasing and supply management and overall company operations?

To help to answer this main research question and support it, following sub-research questions are presented:

2. What are the main barriers for reducing the use of SVHCs?
3. What is the impact to purchasing costs if certain SVHCs components are substituted with SVHC-free components?

4. What are the potential benefits of more sustainable supply chain by the reduced use of SVHCs?

1.3 Key concepts and definitions

The following key definitions and concepts are heavily related to the topic of the thesis and their meanings in the context of the study are opened next. A more comprehensive analysis and connecting the key concepts to the existing literature is provided during the theoretical section of the thesis.

Purchasing and supply management (PSM) is mentioned several times in this thesis and in the context of this study it is one of the company departments. These days PSM is considered to be a critical company function, which is handling the basic operational purchasing process of acquiring required goods and services to the company, but also handling the stakeholder relationships in the multi-tier supply chain networks (Bäckstrand, Suurmond, van Raaij & Chen, 2019). *Supply chain management (SCM)* is a wider concept which includes the management of the whole network of supply chain level relationships between the company and its supply chain stakeholders to facilitate value creation, customer satisfaction and profit maximization. SCM includes the management of both physical supply chain level such as the flow of goods but also the intangible level such as the flow of money. (Toorajipour, Sohrabpour, Nazarpour, Oghazi & Fischl, 2021) Purchasing is the key process of SCM. Figure 1 clarifies the comprehensive meaning of SCM and how SCM works as a link between company functions.

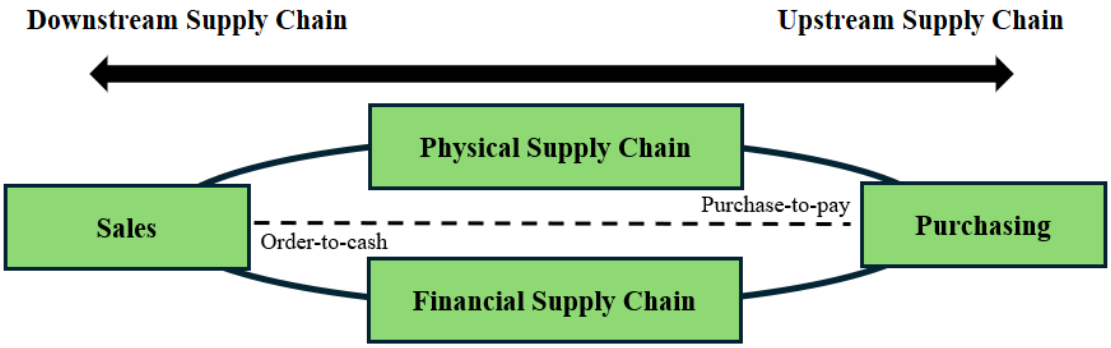

Figure 1. SCM interconnections to company operations (adapted from Toorajipour et al. (2021) SCM definition)

Substances of very high concern (SVHCs) in the context of this study mean different articles and components containing these dangerous and hazardous substances, which are declared to be dangerous for humans, animals and environment for being toxic, carcinogenic, mutagenic or very harmful to the environment due to their toxicity (Klaschka, 2017). Since 2021, companies importing, supplying or manufacturing SVHCs articles in the EU have been demanded to declare and report them to the SCIP database of ECHA (European Coatings, 2021).

Reducing the use of SVHCs is part of the actions related to *Sustainable Supply Chain Management (SSCM)*, which means the SCM does not hurt environmental or social sustainability systems, while still producing economic profit (Pagell, Wu & Wasserman, 2010). Kähkönen, Lintukangas and Hallikas (2018) also note that SSCM must consider all three aspects environmental, social and economic. The outcome and goal of SSCM actions should be the creation of *Sustainable Supply Chain (SSC)*, which performs well in the traditional financial and profit related performance measurements of supply chain, while also generating environmental and social benefits. (Kähkönen et al., 2018) SSC can continue to operate and do business forever, if the customers allow it (Pagell et al., 2010).

Closely related to achieving SSC, is the concept of *Triple Bottom Line.* Coming from the words people, profit and planet and meaning how companies must focus on each of these three aspects to be truly sustainable (Pagell et al., 2010). This is often a challenge for companies especially at the whole upstream and downstream supply chain level and examples from large multinational corporations can be found, which highlight and emphasize their environmental sustainability improvements, but are at the same time facing criticism from social sustainability aspects (Huq, Chowdhury & Klassen, 2016).

While working to improve the supply chain sustainability and moving towards the truly SSC, the companies must always aim for new benefits and value this process can create to the company and whole supply chain network. Even if certain costs can increase in the short-term, a bigger picture should be seen and realized how this development is inevitable and causes benefits in the long-term and allow business to operate with less problems in the future. For this reason, the aim of supply chain sustainability improvement should also be *Triple Value Creation*, meaning the focus is on creating new value and benefits in three levels: company, suppliers and customers (Kähkönen & Lintukangas, 2018).

The following conceptual framework (Figure 2) presents the basic conceptual idea of this thesis and investigation. The overall main theme and concept is a SSC, which the company is aiming to move closer by reducing the use of SVHCs. The empirical part focuses on the problems and barriers the company may face when aiming to reduce use of SVHCs, benefits and advantages coming from the process and deep down the overall impact it has to the PSM and the whole company.

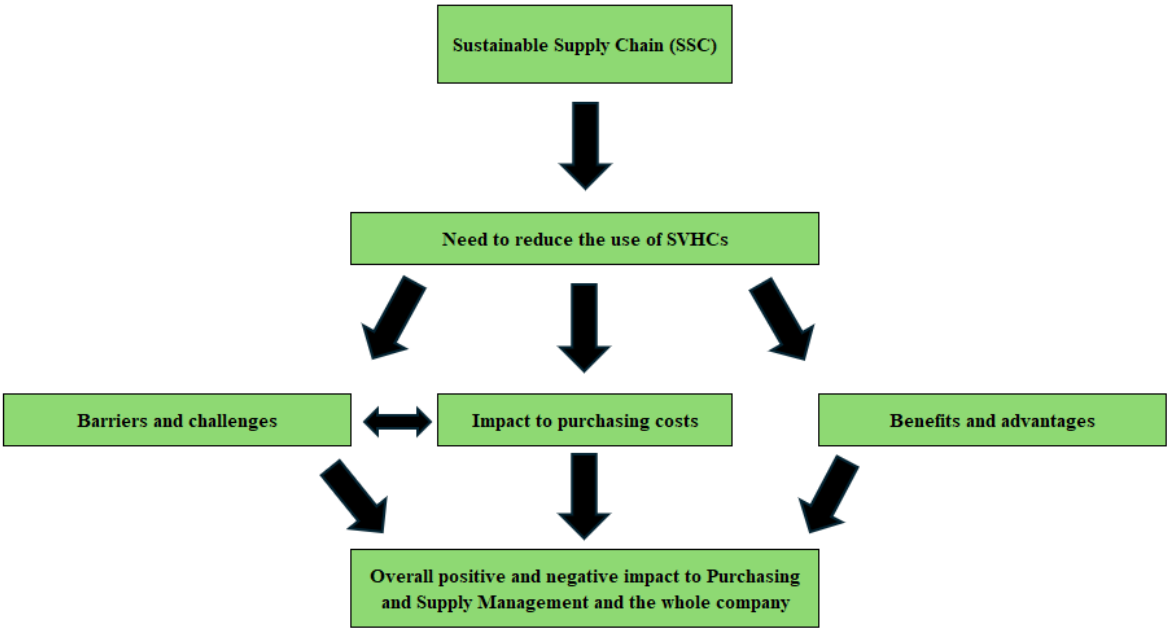

Figure 2. Conceptual framework

1.4 Research methodology

The main source of data in the empirical section of this thesis is qualitative interview data collected from the several representatives of the case study company. In addition, the interviews are made with important customer representatives to analyse and understand the customer's perspectives regarding the research questions and themes of the thesis. Similarly, few important and closely topic related suppliers are interviewed. Empirical section investigation also utilizes some quantitative, numerical data when answering the research question of how the purchasing costs can change.

The analysed data is compared to the findings of the theoretical section by discussion to answer the research questions and own implications are made based on the findings of the thesis utilizing content analysis methods.

1.5 Limitations

This study investigates the barriers for reducing the SVHCs and improving the supply chain sustainability, less focus is paid on the solutions to mitigate these barriers since it requires work and resources from several departments from the company and not just the PSM. In the same way, most focus on this study is the PSM department and how reducing the use of SVHCs impacts its operations. Still at the company level, reducing the use of SVHCs impacts almost every department inside the company and internal collaborative work is needed to solve these challenges, which is also discussed.

The study investigates the impact to purchasing cost when substituting SVHCs components with SVHC-free components, however, this ignores the total cost of the whole process, what companies must consider in practice. Purchasing cost alone tells estimation of how much the costs can change but in addition to this, hidden costs come from several departments of the company regarding redesigning, testing and manufacturing if components can be substituted. It means that the actual increase in total costs can be much higher than what the purchase price change is.

In addition, the company has number of end-products containing SVHCs, which is why the analysis regarding the purchasing costs change is limited to certain important and major products which contain SVHCs items, which gives a good estimation of the change in purchasing costs, but still understanding the limitations that the change may not be totally similar in all components and end-products.

This study is also the perspective of one technology sector manufacturing company operating globally. Generalisation of the study results can be harder if a company is operating in the different business sector or is not a manufacturing company, which needs to purchase items and components that include regulated SVHCs.

1.6 Thesis structure

The figure 3 shows the basic structure of this thesis and investigation, which follows the common structure of academic research including the introduction, theory chapter, methodologies, empirical research and the discussion / conclusions.

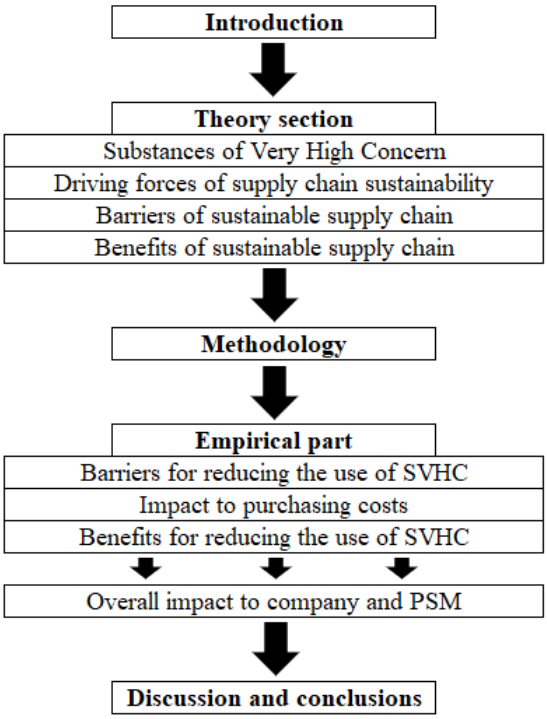

Figure 3. Thesis structure

The next chapter is theoretical were previously known material and academic writings are presented regarding the topic and research questions, which lays foundation for the empirical investigation. It is followed by methodology chapter which outlines the research case, data collection and investigation methods. After this the actual research and investigation is carried out in the empirical chapter and finally by discussion and conclusions, the study is summarized, and answers are provided to the research questions and presented how results of this study differ and coincide from the previous findings regarding the information presented in the theoretical section.

2 THEORETICAL BACKGROUND FOR THE INVESTIGATION

The second chapter is theoretical, which creates foundation for the thesis' empirical investigation and introduces the key topics, which the reader needs to understand regarding this thesis to provide fundamental understanding and background information before the empirical research is carried out and study results presented.

Theoretical section begins by introducing the SVHCs, related obligations, enforcing and the future SVHCs in more detail. This is followed by the theoretical review of external forces which pressure for companies' sustainability improvement to provide the reader more comprehensive understanding of why companies must move towards the SSC. Theoretical section ends by presenting the previous literature findings regarding the known barriers and benefits of what companies face regarding the supply chain sustainability improvement, which lays the foundation for empirical section's investigation.

2.1 Substances of Very High Concern

Last decade the EU has taken stricter stance regarding the SVHCs for their toxic and hazardous nature. The SVHCs are dangerous to humans, animals and the environment for being carcinogenic, mutagenic and often very persistent, which causes environmental issues. Many of SVHCs are especially dangerous and toxic for reproduction, which is why companies using them directly or indirectly must consider both environmental sustainability problems and social sustainability issues regarding the human workforce. (Klaschka, 2017)

The SVHCs are connected to the REACH regulation of the EU coming from the words *Registration, Evaluation, Authorisation and Restriction of Chemicals*, which brings a legal obligation for suppliers of SVHCs items to inform the users from the presence of SVHCs (Klaschka, 2017). The REACH regulation lists SVHCs to the candidate list of ECHA, and suppliers, manufacturers and importers of these substances must pay attention to meet the regulations and follow the list which is being updated with new SVHCs regularly (Coria et al., 2022). The first REACH regulation related candidate list for SVHCs was published in

October 2008, when ECHA added first 15 SVHCs to the candidate list (Deffree, 2009; ECHA, 2024b). In general, the candidate list is updated twice a year, and for example, in 2017 it included 173 substances (Klaschka, 2017). As of December 2024, the candidate list includes 242 SVHCs (ECHA, 2024b).

The key aim of REACH is the protection of human health and environment. When a new substance is added to the candidate list of SVHCs, the process for authorisation starts, meaning that this substance can be added to the SVHCs authorisation list in the future after a prioritisation process of analysing the substance and its use. (Coria et al., 2022) If a substance is added to the authorisation list, a sunset date is set for it and the use of it is banned after that unless the company receives a special permission to use it, a positive authorisation decision, from the European Commission. By December 2024, there are 59 SVHCs in the authorisation list of ECHA. (ECHA, 2024d)

REACH applies to all chemicals in the EU, used both in the industrial processes and daily lives of people. Companies must identify the chemicals they are using and effectively manage the risks regarding them. It requires transparency regarding reporting and communication from the use of chemicals. (ECHA, 2024e) REACH regulation is considered highly important and something that must be continuously monitored and updated by the EU and ECHA, because in 2016 European Environment Agency estimated that over 60 % of the chemicals used in the EU were dangerous and hazardous to human health (Coria et al., 2022).

In the context of this thesis, the most significant SVHC is lead (Pb), which was included in the SVHCs candidate list in 2018 (ECHA, 2024b). Despite this lead is still common in many electronic components as many component manufacturers are still using it for instance in solder, which causes challenges for companies, as the regulation also applies if lead is used in solders (Robin, 2018). Already 2 decades ago, Pan, Wang and Shaddock (2005) noted how there is a need to replace lead containing solder with lead-free solder in electronic industry due to health and environmental issues. Despite this the lead is still commonly used by many manufacturers as it has certain characteristics which makes it efficient and resistant, in addition to being cost effective. (Robin, 2018; Pan, Wang & Shaddock, 2005) Lead is in the SVHCs candidate list by ECHA, which gives obligations for reporting and declaring, but the use is not totally banned. However, lead has been recommended for authorisation list already 11 times, which increases the chances of it being authorised in the coming years. (ECHA, 2024g) Schneider (2022) noted that companies must act now as the likelihood of

lead being authorised by ECHA is becoming high, which can cause widespread challenges in many industries. ECHA has identified lead as priority metal for authorisation and considers that over 90 % of lead products manufactured or imported in EU should be in the scope of restriction by authorisation (Schneider, 2022). In April 2023, the statement from ECHA noted, *"to protect workers and environment, ECHA recommends that the European Commission adds eight substances, including lead, to the REACH Authorisation List."* (ECHA, 2023) If exemptions to the use of lead would be given, these could be for example given to the military and defence industry where lead is also commonly used (ECHA, 2022). Other critical sector where lead is used is a space industry. The trade association of the European Space Industry also recognizes that the major concern related to lead is tin-lead soldering in electronic components. Despite this, they have opposed the suggestion of including lead in the REACH authorisation list, and lobbied EU and ECHA from their point of views, as they consider lead to be critical in many solutions. (Eurospace, 2024)

If any SVHC is included in the authorisation list, and companies have to continue using it, they must seek for a positive authorisation decision from the European Commission, which is a very bureaucratic, long and costly process including: 1. making the application strategy which includes whole supply chain perspectives, 2. notifying ECHA from the upcoming application at least 8 months before submitting it, 3. preparing the application and needed documents, 4. submitting the finalised application, 5. engaging in opinion development and consultation of application and 6. fulfilling the obligations after the commission's positive or negative decision. If a company receives a positive decision, they are in the review period and they must submit a new report and justification at least 18 months before the end of period, if they must still use the banned substance. (ECHA, 2024h)

In addition to REACH regulation, there are also some other important chemical and hazardous substances related regulations in EU, which are sometimes overlapping with the REACH. EU's RoHS Directive, *Restriction of Hazardous Substances* was launched in July 2006, and it aims to limit the impact of certain hazardous substances in electronic products and components. RoHS substances have a certain maximum concentration amount, which can be allowed in the electronic products. Substances which have been under RoHS directive since 2006 or later, can be also added to the SVHCs list of REACH regulation, and then the EU's authorisation bodies must make sure that there are not conflicting requirements. (Takhar, 2023) For instance, the use of lead (Pb) is already restricted in RoHS Directive, but

the difference is that RoHS has given several exemptions to its use (Enviropass, 2024). In REACH regulation all items which contain at least 0,1 % of any SVHC are regulated. Meaning that an item which meets the RoHS requirements, could still be affected by the REACH. Additionally, certain business industries in Europe can have own lists of restricted substances. For example, the European Rail Industry's latest updated list of prohibited or declarable substances includes 774 different substances and the list is based to the REACH regulation and its requirements (Rail industry substance list, 2024).

2.1.1 Current SVHCs related obligations and enforcement

The main obligations for companies regarding SVHCs are related to reporting duties currently. For items containing any SVHC over 0,1 % weight per weight, suppliers must report and provide information regarding the safe use of them to the customers. The EU region importers or producers must also inform ECHA if their items contain SVHCs. SVHCs suppliers must also provide safety datasheets to the customers. (ECHA, 2024f)

Arguably the most resource consuming obligation regarding SVHCs started in 2021, when companies had to start declaring and reporting their items or products including SVHCs to the SCIP database of ECHA (European Coatings, 2021). SCIP database was opened in October 2020, and it was first a recommendation for companies to submit the SVHCs information to the database but soon became mandatory (ECHA, 2020).

The SCIP database has also faced criticism and caused confusion among the companies operating or supplying items containing SVHCs to EU region. Database applies to all business sectors and companies in EU and gives a legal obligation to submit the data as soon as the threshold limit of SVHCs is passed. The database is based on the EU's action plan for circular economy, but it has been found to be very complex system taking lots of resources from companies. (International Surface Technology, 2021) Database's legal obligation for reporting contains wide range of products, and companies have also struggled to identify is there an obligation to declare based on the SVHCs weight in the item (Qiu, Li, Wang, Lin, Zhang, Ruan & Bashir, 2023). Additionally, many big companies are also using their own portals and tools to cope with the SVHCs related challenges. For example, a German company Siemens is using a BOM Check system where suppliers are expected to report REACH, RoHS and SVHCs related reports. (Anastasio, 2023)

Enforcing duties of these obligations have been placed to each member nation of EU, which must make sure that they have the sufficient system which controls that the legal obligations are met, and EU or ECHA are not directly responsible for enforcing. (ECHA, 2024c) Schenten et al. (2020) note that this has caused confusion since the member states of EU have interpret the legal obligations differently, especially regarding the SVHCs weight limit of 0,1 % in items and how it is measured. In the harmonised pilot project of 15 EU member states for SVHCs enforcement, 55 SVHCs articles that contained over 0,1 % of SVHC per weight were found but the legal reporting obligation was met in only 24 cases out of the 55. (Schenten et al., 2020) Another study regarding the REACH enforcement noted that since the enforcement duty is the responsibility of member states entirely, companies may consider it less strict. In the case of German companies, 224 information requests regarding the SVHCs were not even answered despite being asked from the companies. (Klaschka, 2017)

It was also discovered that companies falsely claimed that they do not have SVHCs items even though they had them. This indicates that the enforcement is not working as well as it should, when it is placed on the duties of each member state. It was also found out that industrial organisations are lobbying in EU to weaken or even eliminate the strict regulations regarding the REACH and SVHCs. (Schenten et al., 2020) This giving pressure for EU, ECHA and each member state of EU to make the enforcement stricter in the future, even if the certain major industrial forces would be opposing it.

2.1.2 The future of SVHCs

The general expectation is that regulations and obligations regarding SVHCs are only getting stricter in the future. New substances are added to the candidate list and eventually the authorisation list increases also, which means the companies must act now to reduce use of SVHCs to save costs and resources in the future. (Klaschka, 2017) Chirsir, Palm, Baskaran, Schymanski, Wang, Wolf, Hale and Arp (2024) noted regarding the *persistent, mobile and toxic substances* (PMT) that only some of these substances have been identified as SVHCs so far, while potentially thousands of similar substances are yet to be investigated and assessed regarding the SVHCs regulations. This inevitably means that the candidate and authorisation list of SVHCs expands in the future. (Chirsir et al., 2024) Coria et al. (2020) also estimate that more items are added to the authorisation list in the future and receiving a

special permission to continue using them may get more complicated. After all, the main idea of the regulation is that one day SVHCs would not be used at all, as mentioned by Klaschka (2017, 11), *"As long as SVHCs are used in articles, exposures and risks are real."*

REACH regulation demands that the SVHCs are substituted by safer alternatives due to their risk, which is important since it is not a suggestion but an order to act. Companies must understand this and not be surprised when regulations get even stricter. (Geueke & Muncke, 2018) However, due to the speed of development of these regulations and very strict limit of how much SVHCs can be used without it being regulated, manufacturers and their customers are facing significant challenges to replace the items which include SVHCs. Replacement may not even be possible for all items without the upstream manufacturer developing totally new SVHC-free items. (Lebeuf, Preischl, Gaudin & Aubry, 2024)

Previously many have regarded the violation of SVHCs regulations as trivial, minor offence, which must not be accepted in the future since it is a wrong signal for those companies who take SVHCs regulations seriously (Klaschka, 2017). Federal law was passed in Germany in 2023, which notes that wilfully or negligently made incorrect SVHCs reporting to the SCIP database results a fine up to 10 000 € per case. The fine can get very significant if a company ignores the reporting totally as companies usually have several SVHCs containing products which each require a SCIP database notification. (Friedrichs, 2023) In Germany, companies may also get a fine up to 1 million EUR, if they ignore the REACH regulation obligations. Company's administrative personnel could be also sentenced up to 5 years in prison and the firm put under juridical supervision. In Finland, regulators can impose a coercive fine which increases systematically until the REACH obligations are met. For serious violations, sentence of up to 6 years in prison could also take place. In France, in addition to financial penalties, the company department where the REACH violations took place, can be shut down definitively or for 5 years. (CIRS, 2020, 14) Additionally, in 11 EU countries Austria, Bulgaria, Czechia, Greece, Hungary, Latvia, Lithuania, Portugal, Romania, Slovakia and Slovenia the penalties for REACH violations are only possible to be given as administrative penalties, not as criminal law penalties, which makes the enforcement less serious (CIRS, 2020, 11–19). This shows, as noted by Schenten et al. (2020), how different member states of EU enforce the REACH regulations in the different way and there is a lack of unity, which makes the situation between different companies in EU unequal.

2.2 Driving forces for sustainability in the SCM

External forces are driving and forcing companies to improve their sustainability and aim for SSC. The chapter presents how the companies are being pressured by the stakeholders and regulated by regulators to make sustainable supply decisions, improve their supply chain sustainability and implement it to the core business strategies and values of the firm. The chapter begins by presenting the sustainable supply decision and how it is connected to the topic of the thesis.

2.2.1 Sustainable supply decision

Companies are facing increasing pressure for sustainability improvement in their supply chains and are expected to be able to control the whole supply chain level sustainability risks by the stakeholders. Due to *supply chain liability effect* even downstream, end-product supply chain companies can suffer reputational and financial damage from the sustainability issues that are happening far beyond their direct control in the upstream of the supply chain (Meinlschmidt et al., 2018) There are many ways how companies can improve their supply chain sustainability, it can be done for example by investing in the use of renewable energy or improving the recycling process of the company (Shahzad, Rehman, Zafar & Masood, 2024). In the context of this study, the way company is aiming to improve the supply chain sustainability is by reducing the use of hazardous SVHCs, which is related to the supply decision of substituting these SVHCs containing components with more sustainable options.

Wu and Pagell (2011) noted that the challenge of sustainable supply decision making is to ensure companies can operate financially feasible, while also considering the environmental aspects of the supply decision. This is a trade-off between optimal financial success and overall sustainability. Some companies are already making extensive investments on sustainability, even if it hurts the financial success in the short-term. (Wu & Pagell, 2011)

These days companies are also expected to pay attention to not only environmental sustainability but all aspects of *triple bottom line* of people, profit and planet. Sustainable supply decision considers the environmental aspects (planet), social aspects regarding the labour and workforce (people), while also generating financial profit, which is historically the most important thing of the SCM. Companies do not survive without the financial profits

but the stakeholders' expectation these days is that it is achieved in a sustainable manner. (Kähkönen et al., 2018; Pagell et al., 2010)

Important part of sustainable supply decision-making is also the supplier selection process. Companies must aim for a sustainable supplier selection process which considers all three aspects of triple bottom line sustainability when selecting the suppliers. (Karakoç, Memiş & Sennaroglu, 2023) Sustainable supplier selection must go beyond the first-tier supplier level and also focus on the environmental and social sustainability impacts of the sub-suppliers upstream in the supply chain. This requires the monitoring and evaluation of suppliers' performance and close collaboration with the supply chain partners to ensure sustainable supply decision-making (Zimmer, Fröhling & Schultmann, 2016).

Companies operating with SVHCs containing items are encouraged, pressured and regulated to reduce use of these components and substitute them with SVHC-free options, which is creating challenges for them in many levels (Lebeuf et al., 2024). Replacing SVHCs components with SVHC-free options is an example of a sustainable supply decision, what companies can make. Supply decision like this can improve both environmental and social sustainability, since these hazardous substances are dangerous to both nature and humans, while also considering the economic side that the use of SVHCs is getting more expensive and difficult all the time due to stricter regulations (Klaschka, 2017).

Companies should always aim for *sustainable sourcing or purchasing*, which means managing the supply decision and operational purchasing process by considering the triple bottom line sustainability in the whole upstream supply chain level of the purchased items (Pagell et al., 2010). Companies utilising sustainable sourcing are basing their supply decision on all aspects of sustainability and evaluating the supply process and suppliers constantly regarding the sustainability performance. The aim should be the joint-collaboration and mutually beneficial relationship with the suppliers which is generating value to both the supplier and focal company. (Li, Shan, Shou, Kang & Park, 2023) In addition to supplier and buying company perspective, and mutually beneficial relationship between these two supply chain partners, the customer perspective should also be considered which creates the concept of *triple value creation* and how improving the supply chain sustainability, for instance by reducing the use of SVHCs, can bring benefits and new value to the buying company, suppliers and the end-customers. (Kähkönen & Lintukangas, 2018).

Figure 4 connects the concept of triple value creation by Kähkönen and Lintukangas (2018) and triple bottom line sustainability concept (Pagell et al., 2010) and presents how companies must understand and connect these two concepts in their supply chain sustainability improvement and decision-making.

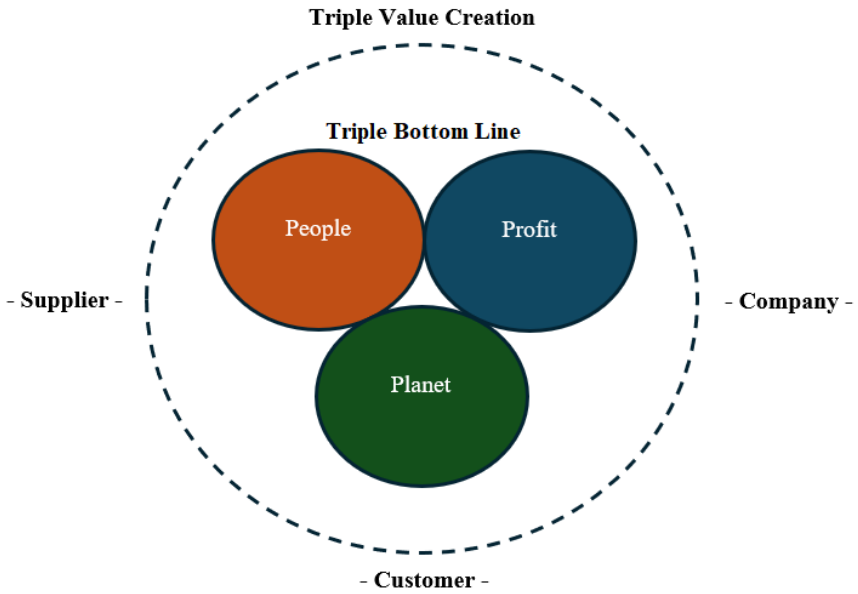

Figure 4. Triple Value Creation and Triple Bottom Line sustainability (adapted from Kähkönen and Lintukangas (2018) and Pagell et al. (2010))

Companies have the moral obligation and are expected by the stakeholders to act in a right way, which is being as sustainable as possible (Montiel, 2008). Additionally, increasing sustainability related regulations and laws are bringing new legal obligations for companies to answer sustainability regarded challenges in their supply chains (Sandau, Henninger, Garbade-Jones, Hartmann & Völkers, 2023). Zimmer et al. (2016) noted that last two decades tightening regulations and stakeholder pressure are the key factors which demand companies to focus on sustainability in their supply chains.

2.2.2 Stakeholder pressure

Brand is one of the most valuable assets of a company. Any event which can weaken the overall image of the company and its brand, can lead to significant financial losses and reputational damage by reducing the customers and sales. Currently, these kinds of events are usually related to supply chain sustainability issues and stakeholders concerns about

them which are ignored. (Lintukangas, Kähkönen & Ritala, 2016) Stakeholders mean any groups or individuals who can influence the company or are influenced by its activities (Meixell & Luoma, 2014). Stakeholders are often classified into primary and secondary stakeholders. The primary stakeholders are own employees, customers, shareholders and legitimate regulator bodies including the government. The secondary stakeholders are media and several non-governmental organizations, which can often give pressure to the company regarding the sustainability or expose the wrong doings. (Shahzad et al., 2024)

However, stakeholder pressure is not similar for all companies, and it can vary. Sustainability related crises in the supply chain can increase the pressure from stakeholders, while the firm size and publicity is also affecting the pressure it receives from stakeholders regarding sustainability. (Huq et al., 2016) Lintukangas, Arminen, Kähkönen and Karttunen (2023) noted regarding carbon management actions in the supply chain that companies must make sure their political activities and external communication is in line with the actual sustainability improvement actions, or they can be blamed from hypocrisy. Especially regarding the large companies which face more pressure and attention from the stakeholders. (Lintukangas et al., 2023) This same finding can be also applied to other supply chain sustainability related challenges such as the SVHCs.

Sustainability standards and certifications such as ISO-certifications have also become an important driver for sustainability implementation and something what stakeholders can demand from the companies and pressure them to acquire (Lintukangas et al., 2016). Customers and suppliers can for instance demand that a company has ISO 14001 certified environmental management system, and they only accept firms with this certification as business partners (Treacy, Humphreys, McIvor & Lo, 2019).

Almost every firm is facing pressure for sustainability from their own customers and closest stakeholders, but especially global multinational corporations are also facing similar pressure from media, non-governmental organizations and activists (Huq et al., 2016). Meixell and Luoma (2014) studied stakeholder pressure and SSCM and found that pressuring can have positive consequences also by increasing the awareness regarding SSC in the company, make companies set new goals for sustainability and implement more SSCM practices. However, if things are done wrong, stakeholders can also mobilize public opinion against the company, which can cause serious problems and even jeopardize the future of the company. (Meixell & Luoma, 2014)

Roehrich, Grosvold and Hoejmose (2014) found that while the financial costs were the most important thing influencing the SCM, the external pressure and risks of reputational damage influenced a lot that companies considered they must move towards SSCM practises. Vidal, Spetic, Croom and Marshall (2023) were able to confirm previous findings that the stakeholder pressure is one of the key factors impacting companies to implement SSCM practices. However, they found out that after certain level of sustainability orientation at the company, the stakeholder pressure weakens (Vidal et al., 2023), which indicates that with effective SSCM actions companies can achieve the status of a good company regarding sustainability and operate with less external pressure.

2.2.3 Regulatory pressure

Increasing legal obligations are also affecting heavily that companies must move towards SSC and implement SSCM practices. This became already visible in the 2.1 section of this study presenting the SVHCs and the regulations regarding the use of them. Regulations such as REACH obligate companies in EU to collect sustainability information from their suppliers and gives legal obligations, which must be fulfilled regardless of the size or business sector of the company (Meinlschmidt et al., 2018). Regulation authorities, governments, trade bodies and unions are increasing demands for sustainability and companies must meet these or face risk of sanctions (Huq et al., 2016). The moral obligation and pressure from stakeholders to act sustainably is no longer enough, when there is also the legal obligation from the regulators.

National governments and EU are implementing and enforcing new regulations and directives regarding SSCM, protection of environment and human rights, and sustainability reporting (Sandau et al., 2023). In April 2024, EU approved the *CSDDD Corporate Sustainability Due Diligence Directive* also known as EU Supply Chain Act. In the future, the law obligates large corporations in EU with over 1000 employees or turnover of €450m or more to identify supply chain risks related to human rights and environmental risks. Despite not obligating small and medium sized corporations to similar procedures, these firms are still impacted from the law as suppliers to these large corporations. (EQS Group, 2024) Since 2023, EU's *Corporate Sustainability Reporting Directive (CSRD)* has demanded large corporations report the impact of their business operations to environmental

and social sustainability systems in a transparent and public manner. From 2025 the CSRD impacts companies meeting 2 out of 3 from these criteria: total assets over €20 million, turnover over €40 million, and over 250 employees. From 2027, the directive also affects all small and medium sized listed corporations in EU. (Sandau et al., 2023) In 2023, the EU also launched another sustainability improvement related regulation and obligation for companies when *Carbon Border Adjustment Mechanism* (CBAM) was launched. It requires that any company or individual which imports for example products made from iron, aluminium, steel or certain chemicals worth over €150 from the outside of EU to declare and report the emissions from the production process of these goods to the CBAM registry. CBAM is still in a transition phase but from 2026 the importers are demanded to acquire authorised CBAM declaration certification from the customs and purchase emissions certificates to compensate the emissions of imported goods. (Finnish Customs, 2024) The regulation is not directly connected to the topic of this thesis but shows the wide range of new sustainability obligations what companies are facing, consuming lot of resources to fulfil and are often in the responsibility of PSM department.

EU member states can also implement similar laws to their own jurisdiction system, which must be unified with the EU laws to make sure there are no contradictory demands. German Supply Chain Due Diligence Act entered force in 2023, obligating corporations with over 1000 employees for similar human rights and environment risk identifying in the supply chains than EU's Supply Chain Act. The law has also been considered highly bureaucratic, confusing and resource consuming by the companies and has been labelled as one of the most controversial legislation projects of recent times in Germany. (Buttke, Schötteler, Seuring & Ebinger, 2024) Schenten et al. (2020) already found that industrial organizations and large corporations are often lobbying in EU against these new laws and regulations.

It is still unlikely that any change would happen that weakens or reduces the sustainability regulations and obligations that companies are facing now and in the future. EU has made it clear that sustainable development is its primary goals for the future and is bringing new sustainability requirements for the companies related to the CSRD, supply chain transparency and use of hazardous substances, among other things. In fact, in 2019, the European Commission stated that they consider companies are focusing too much on the short-term financial metrics over the long-term comprehensive sustainability and sustainable business practices. (Miettinen, 2024) It is clear that this thinking can cause tensions between

the companies and regulators, especially when the global competition between the companies is getting tougher and European companies must compete by cost and efficiency versus companies in other regions of the planet where similar regulations may not be present.

Sustainability related obligations can also cause tensions at the internal company level or whole supply chain level while collaborating with the stakeholders. As identified by Zehendner, Sauer, Schöpflin, Kähkönen and Seuring (2021), conflicting requirements the companies are facing while improving the supply chain sustainability are common and can cause *paradoxical tensions*. One of the most common paradoxes is the need to achieve short-term financial profit while also aiming for long-term comprehensive sustainability. Improving sustainability often brings extra costs at the short-term. Historically companies have prioritised financial measurements and profit over everything else, but this perspective is no more enough to answer today's sustainability challenges and strict demands and pressure for improving the sustainability from both the regulation bodies and the stakeholders. (Zehendner et al., 2021) The companies can not escape these regulations, which requires a change in the way of thinking. Instead of seeing the sustainability and financial success as either–or situation, it should be seen as both–and scenario. The companies must also focus on the benefits of improvement sustainability and not just the increased costs it may cause in the short-term. (Zehendner et al., 2021)

2.3 Barriers to implementing SSCM practices

This chapter focuses on the known barriers and problems the companies are facing when aiming to improve the supply chain sustainability, which creates important foundation for the empirical section's investigation part of this thesis when it is investigated what barriers the company may face when trying to improve the supply chain sustainability by reducing the use of SVHCs containing components.

The increasing costs of improving the supply chain sustainability have been labelled as one of the biggest barriers for achieving the SSC in the previous research. Companies often face increasing costs when utilizing social-ecological practices to improve supply chain sustainability, which can be seen in the increasing costs of products and services. This causes tensions with the classic aim of profit maximation and need for financial performing, which is why many companies have prioritized economic success over the sustainability objectives.

(Zehendner et al., 2021) Lintukangas et al. (2016) found that the financial conditions of the firm and costs of sustainability were the biggest barriers for implementation of SSC. The companies with healthy and successful economic performance are utilizing more SSCM practices, which is not surprising since these companies have more financial resources to implement sustainability if it brings extra costs in the short-term (Lintukangas et al., 2023).

The high cost and lack of financial resources for supply chain sustainability improvement is also found to be a major barrier both by Narayanan, Sridharan and Kumar (2019) and Menon and Ravi (2022). In the study by Roehrich et al. (2014) manager of a company noted that they are not judged by sustainability performance but mainly by costs and other financial margins, and currently sustainability improvements are coming with extra cost. Interviewees still recognized that they must consider also the long-term benefits and development regarding the supply chain sustainability. (Roehrich et al., 2014) Especially when talking about the large, publicly listed corporations, receiving the shareholders' understanding and acceptance for sustainability improvements which can hurt the financial performance of the firm in the short-term can be difficult (Shahzad et al., 2024).

Companies must have clearly set goals for the short-, medium- and long-term regarding the sustainability improvements. Stakeholders must be made to understand the benefits of sustainability supply chain in the long-term and not be short-sighted. (Shahzad et al., 2024). Improving sustainability at the expense of financial profit can inevitably cause paradoxes in the short-term but companies must be prepared to the future and understand the long-term benefits of sustainability (Zehendner et al., 2021). Lack of understanding of the benefits of sustainability and lack of clear short- and long-term goals have found to be barriers for supply chain sustainability implementation. (Menon & Ravi, 2022; Lintukangas et al., 2016)

Companies can not successfully aim for SSC without it being in the strategies of the firm and having a strong top management support. The corporate culture, backed up by the top management, must foster sustainability improvement and consider it key aspects of the firm. (Narayanan et al., 2019) If the top management is not giving support for the sustainability improvement there are lack of resources to achieve it and the corporate culture is not paying attention to it sufficiently (Menon & Ravi, 2022). Lack of understanding and consensus at the top management level is recognized to be a significant barrier for sustainability improvement in the supply chain by Lintukangas et al. (2016).

SSC improvement is also requiring lots of internal company resources from several departments of the firm, which can cause barriers to implementation. Companies need to set-up cross-functional teams consisting of employees from several departments to answer to the multidimensional supply chain sustainability challenges and new regulations' demands. (Sandau et al., 2023) SSCM and aiming for SSC requires enough resources for the PSM department of the company and commitment to sustainable practices and values, but PSM is only one part of the company's functions and overall sustainability requires cooperative work between all company functions and departments, which can be a challenge and barrier due to insufficient resources. (Kähkönen et al., 2018)

Therefore, the implementation of SSC can also be more difficult for smaller companies. Large corporations have more resources that can be shared for sustainability improvement, and they are also facing more external pressure to achieve it. (Lintukangas et al., 2023; Lintukangas et al., 2016) Still even large corporations may often lack the sufficient resources and capabilities to implement supply chain sustainability comprehensively throughout the whole supply chain, and many companies have been forced to use external consultants, which bring extra costs (Roehrich et al., 2014).

Barriers for supply chain sustainability implementation are also coming from company's power relations and ability to influence whole supply chain including the key suppliers and their sub-suppliers. The buying firms are usually responsible only for a small percentage of lower-tier supplier's sales, which causes barriers to influence the supplier i.e. regarding the sustainability. (Meinlschmidt et al., 2018) In the study by Zehendner et al. (2021) manager of a multinational enterprise noted that sustainability improvement can not be done by the single company alone, even as a large, global corporation. This is because supply chain sustainability challenges are going past several layers of supply chain and require collaborative work in the whole supply chain level. (Zehendner et al., 2021)

Active cooperation with supply chain members and working together to achieve SSC is needed to cope with the barriers regarding the power and ability to influence the whole supplier base (Lintukangas et al., 2023). PSM must be recognized as a strategic function inside the company, and it needs sufficient resources to cope with today's grand challenges such as the sustainability. In past, PSM has been often seen as a supportive function for other departments in the company, but this kind of thinking should change when companies are competing against other companies in the efficiency, reliability and sustainability of the

supply chain. (Kähkönen & Lintukangas, 2012) It is also required to understand the perspectives of entire supply chain and recognize that the aim of improved supply chain sustainability, for instance by reducing the use of SVHCs, should be that it can generate new value and benefits to company itself, customers and suppliers, as per triple value creation concept (Kähkönen & Lintukangas, 2018).

Active collaboration with suppliers and other companies in the supply chain is also needed as, due to fast speed of development of sustainability regulations and obligations, companies are facing barriers for SSC from the lack of sustainable suppliers. Emphasis on sustainability decreases the availability of accepted suppliers and the problems may increase even more if the company is accepting only suppliers with certain certifications or standards regarding the sustainability and quality such as ISO 14001 and 9001. (Shahzad et al., 2024) Lack of new sustainable materials, technology and processes is a clear barrier for SSC development. All materials used are not sustainable, while the lack of innovation, motivation and resources is leading to a situation where the development of more sustainable options is lacking behind. (Narayanan et al., 2019; Menon & Ravi, 2022)

Lebeuf et al. (2024) noted especially regarding the SVHCs that currently companies are facing problems that there are limited number of options available for SVHC-free components, and not all suppliers are prepared for the stricter EU regulations. Menon and Ravi (2022) also noted that sometimes suppliers have negative attitude on supplying more sustainable materials, and they refuse to change the traditional unsustainable materials or production methods, leading to barriers of sustainability development in the supply chain. Bhandari, Garza-Reyes, Rocha-Lona, Kumar, Naz and Joshi (2022) emphasized how scarcity in the market and lack of sustainable items, and their suppliers is a barrier to supply chain sustainability, and using more sustainable options can lead to increased prices, longer lead time and production costs rise.

A situation like this can lead to *sole sourcing* scenario, where the buyer has only one possible supplier for certain components (Li & Debo, 2009), which can increase the supply risks such as disruptions in supply, which companies often can not accept regarding the critical components even if the sole sourcing supplier option would be more sustainable.

Several studies have also highlighted how cultural differences between the buying organization and supplier are often obstacle to collaboration regarding the sustainability

improvement and therefore a barrier for SSC. Zehendner et al. (2021) noted how cultural differences and perspectives regarding sustainability often cause tensions between the supply chain partners. Moretto, Patrucco and Harland (2020) presented how Western companies had problems managing relationships with Asian suppliers due to cultural differences. Meinlschmidt et al. (2018) also noted how the cultural and regulation differences between suppliers from China and other emerging markets and European companies caused problems to the collaboration.

However, it should not be considered that the focus on improving sustainability is only taking place at the Western countries. EU and China, for instance, have cooperation programmes related to circular economy, climate change and environmental protection, and increasing focus on sustainability is paid in China when they are witnessing the negative effects of climate change and global warming (European Union, 2020). At the moment, sustainability regulations in EU are definitely stricter than for example in China, but many industry advisers in China are suggesting that Chinese firms must adopt and answer to these regulations and consider them a competitive advantage, or they face a risk of reputational damage in the eyes of Western market (Ng, 2024).

Large part of previous literature has mentioned the lack of clear sustainability regulations, standards and legislation as a barrier for supply chain sustainability implementation (Menon & Ravi, 2022; Narayanan et al., 2019; Lintukangas et al., 2016). However, currently this can be connected more to other business regions in the world than EU, since the EU is pushing hard to implement new sustainability regulations and companies regardless of their size or sector are being impacted by them (Sandau et al., 2023). In EU, the bigger challenge could be the actual enforcement of all sustainability regulations, especially if it is expected that each member state should enforce them on their own such as with the SVHCs related regulations. This causes lack of unity in enforcement and can be a barrier for SSC improvement since all member countries and companies from them may not take the regulations as seriously. (Schenten et al., 2020)

The following table 1 summarizes the presented known barriers of SSC improvement by dividing them into internal company level and entire supply chain level barriers, showing that companies can not focus only on internal challenges, but the perspectives of entire supply chain must be recognized.

Table 1. Sustainable supply chain barriers

Sustainable supply chain barriers	
Barriers	**References**
Internal company level	
1. Company size and financial success.	Lintukangas et al. (2023); Lintukangas et al. (2016)
2. Lack of clearly set goals and targets for sustainability.	Shahzad et al. (2024); Zehendner et al. (2021)
3. Lack of understanding on the benefits of sustainability.	Shahzad et al. (2024); Menon & Ravi (2022); Zehendner et al. (2021); Lintukangas et al. (2016)
4. Lack of top management support for sustainability.	Menon & Ravi (2022); Narayanan et al. (2019); Lintukangas et al. (2016)
5. Sustainability not implemented in the core values, culture and strategies of the firm.	Menon & Ravi (2022); Narayanan et al. (2019)
6. Lack of sufficient resources for purchasing and supply management.	Kähkönen et al. (2018); Roehrich et al. (2014); Kähkönen & Lintukangas (2012)
7. Lack of cross-functional collaboration inside the different company departments.	Sandau et al. (2023); Kähkönen et al. (2018)
Supply chain level	
1. Increased total costs including the purchasing cost.	Lintukangas et al. (2023); Menon & Ravi (2022); Zehendner et al. (2021); Lintukangas et al. (2016); Narayanan et al. (2016)
2. Lack of leverage and influencing power on the suppliers.	Lintukangas et al. (2023); Zehendner et al. (2021); Meinlschmidt et al. (2018)
3. Lack of supply chain level collaboration.	Shahzad et al. (2024); Lintukangas et al. (2023); Zehendner et al. (2021)
4. Lack of sustainable material / component suppliers.	Lebeuf et al. (2024); Shahzad et al. (2024); Menon & Ravi (2022); Bhandari et al. (2022); Narayanan et al. (2019)
5. Cultural differences and varying perspectives of sustainability.	Zehendner et al. (2021); Moretto et al. (2020); Meinlschmidt et al. (2018)
6. Lack of clear sustainability regulations or enforcement of them.	Menon & Ravi (2021); Schenten et al. (2020); Narayanan et al. (2019); Lintukangas et al. (2016)

By dividing the presented barriers of SSC into internal company level and supply chain level barriers, it is easier to identify whether the barriers can be focused on internally or is a supply chain level collaboration needed to mitigate the barriers.

2.4 The benefits of SSC

This chapter presents the benefits what companies may gain by investing in SSCM and aiming for SSC. The chapter lays important foundation for the empirical section of the thesis where one of the aims is to investigate the potential benefits what company may gain from minimizing the use of SVHCs and moving towards the SSC.

In supply chain sustainability, companies are expected to pay attention to all levels of triple bottom line sustainability of people, profit and planet (Pagell et al., 2010). One of the most obvious benefits of implementing supply chain sustainability is meeting the regulatory demands which companies are increasingly facing, which makes the future business operations easier and reduces legislation related problems and risks of sanctions by getting the lead over the legislation (Ortas, Moneva & Álvarez, 2014). Klaschka (2017) noted that

getting prepared for stricter regulations by starting to invest in the reduction of SVHCs and improving the supply chain sustainability is beneficial since it reduces the future challenges and risks that companies face. Complying with current and upcoming supply chain sustainability regulations reduces the pressure company is facing and makes running the business less risky (Sandau et al., 2023). Roehrich et al. (2014) found out that while companies are facing pressure of complying with increasing supply chain sustainability regulations, firms in many industries are also trying to do more than the regulations require and go beyond them, as they consider it beneficial for preparing to the future in advance.

The aim of stricter regulations is a common good for environmental, social and financial systems by reducing the illegal and dishonourable business practices. Companies may still perceive that increasing regulations are bringing extensive pressure for compliance and consume too many resources (Soni, Prakash, Kumar, Singh, Jain & Dhami, 2020). However, investing in supply chain sustainability can reduce these burdens and the regulations should not be seen only as burden and resource consuming thing but understand the benefits of compliance. Strict sustainability regulations and standards have found to be a prominent barrier for new competitors entering the market area (Lintukangas et al., 2023). It shows that getting the lead over the legislation as mentioned by Ortas et al. (2014), can bring several benefits, reduce potential competitors and strengthen the company's market position.

Improving the supply chain sustainability also brings companies several direct socio-ecological benefits, meaning social and environmental aspects of sustainability, which are the key to traditional view of triple bottom line sustainability (Kähkönen et al., 2018). Improving supply chain sustainability is often related to the better workers' safety and health by making the working environment more sustainable and safer. In addition, the SSC is causing less environmental damage by utilising greener and less problematic or hazardous items and production methods (Soni et al., 2020) Classic aim of many companies when aiming for a SSC is to reduce carbon emissions and mitigate the climate change risks (Lintukangas et al., 2023). In the context of this study, the direct socio-ecological benefits of improved supply chain sustainability are coming from reducing the use of toxic and hazardous SVHCs, which have recognized to be dangerous for both humans and environment (Klaschka, 2017). More than 60 % of substances and chemical used by companies in EU are still hazardous to humans, which is why reducing the use of them causes direct social sustainability benefits of improved health of human workers (Coria et

al., 2022). SVHCs have also found to be very long-lasting and hazardous to environment, animals and ecosystems, which is why minimizing the use of them also directly improves the environmental aspects of sustainability (Klaschka, 2017).

Reducing the use of SVHCs and moving towards the SSC is bringing the company, workforce and whole society several direct socio-ecological benefits from *people* and *planet* aspects for triple bottom line, which is also something that companies should communicate to stakeholders for instance when meeting the EU's CSRD requirements (Sandau et al., 2023), since previous research shows companies are facing several undirect benefits of improved supply chain sustainability such as the improved company reputation. The benefits related to improved company reputation can also come from better grades and positions in different sustainability standards and rankings. For instance, EcoVadis is one of the respected and commonly used sustainability rating standards and it assesses 4 sustainability pillars: environmental, labour/human rights, ethics and sustainable procurement (Lancien & El Rafei, 2023). Reducing the use of SVHCs, can at the minimum improve the ratings in environmental and sustainable procurement pillars, but also potentially in the pillar related to workforce, which all improves the company reputation.

Improving supply chain sustainability has found to foster the brand image of the company (Soni et al., 2020), which is one of the key benefits of SSC, since valuable brand is a critical asset for a company (Lintukangas et al., 2016). According to Sandau et al. (2023) sustainability is the second most important factor influencing the brand value and reputation of the company after quality. Sustainability is especially important for younger people, as even 2 / 3 millennials stated they would be ready to accept a pay cut to work in a sustainable and purposeful company. Improved sustainability enhances the employee and customer loyalty, especially regarding the younger generations. (Sandau et al., 2023) Ortas et al. (2014) also noted that improving supply chain sustainability can improve employee satisfaction and motivation. Common expectation by stakeholders currently is that companies have both social obligations to meet the social norms, i.e. acting sustainably, while also having moral obligations to act as role model for other companies and prioritise sustainability for the common good of our planet (Lintukangas et al., 2022).

Benefits of improved supply chain sustainability are improved stakeholder relationships and company reputation, which can lead to improved market competitiveness (Shahzad et al., 2024). Being sustainable can open new business opportunities and markets, when being

more preferred and wanted partner for customers by improving the reputation and public relations of the company (Ortas et al., 2014). Roehrich et al. (2014) found that investing in sustainability is a must or otherwise the company may lose their competitive advantage over the rival companies. Not investing in sustainability reduces the customers in the future and jeopardizes the future of the company. Market leaders are already showing biggest and most comprehensive focus on sustainability. (Roehrich et al., 2014) Even though, this is also related to the fact that biggest corporations and market leaders are facing most pressure from stakeholders and expectation to be sustainable (Lintukangas et al., 2023). These companies are still setting up common standards and level of expectations regarding sustainability, which brings social and moral expectation for other companies to act in a similar way. Even smaller companies should follow the example set by large corporations regarding sustainability if they aim to compete in the global market (Shahzad et al., 2024).

By being leading companies to implement supply chain sustainability, company can set standards for sustainable business, improve its market share and reputation and pressure other companies to follow the same path (Lintukangas et al., 2023). Soni et al. (2020) consider that the time has come when sustainability is a critical factor for continuous business growth and expansion. Every business which wants to grow globally and expand must realize that credibility and sustainability must be considered equally or even more than short-term financial benefits and profit margin. (Soni et al. 2020) Previous research has proven that for companies to survive they must be able to answer and cope with the key movements of the time more successfully than the rival companies and outperform them. High focus on sustainability is clearly a key movement of our time. (Shahzad et al., 2024)

Investing in supply chain sustainability has also been linked to improved product quality, efficiency and innovation processes, as sustainability is almost always related to higher and more advanced technologies which can improve product quality, foster innovation and reduce lead time when implemented successfully (Soni et al., 2020). Moving to more sustainable business often requires implementing new technologies and materials, which requires supply chain level collaboration to implement sustainability into the manufacturing processes of the entire supply chain (Shahzad et al., 2024). This fosters innovation and can lead to new ground-breaking solutions which improve business profitability and contribute to all aspects of sustainability (Sandau et al., 2023). Outcome of SSC should also be the improved product quality and longer lifecycle of the items used, which improves efficiency

and brings financial benefits (Ortas et al., 2014). As noted by Lebeuf et al. (2024) currently companies may struggle to find SVHC-free items with the same scale than those items which still contain these problematic substances, but this also brings opportunities for innovation and development, inventing something new, which can bring benefits for whole supply chain level. Naturally this requires whole supply chain network level collaboration and willingness to solve these common, global challenges by customers, manufacturers, suppliers and even regulation bodies (Shahzad et al., 2024).

Ultimate advantage and consequence of all benefits regarding the improved supply chain sustainability should also be the improved financial success and profitability. Implementation of SSC often brings new costs in the short-term but should lead to improved financial advantages in the medium- and long-term (Lintukangas et al., 2016). Companies should aim to integrate sustainability and profitability, which can lead to simultaneous benefits (Soni et al., 2020) Recent studies have shown that if companies can combine sustainability and financial elements, they can be especially successful and competitive in the future (Lintukangas et al., 2016).

Companies which are labelled as sustainable are also priced with higher market and stock value than unsustainable firms, as it is expected that these companies are more profitable in the long-run and cope better with future's challenges and risks. Sustainable, high-purpose companies can double their market value even by four times faster than unsustainable companies. (Sandau et al., 2023) In the study by Ortas et al. (2014) regarding SSC and companies' financial performance, a link was found between SSCM practices and higher revenue and financial margins. Implementing supply chains sustainability into manufacturing processes by using more sustainable technologies and components, while also utilizing the benefits of improved company reputation and brand value, should lead to increased revenue and profitability (Shahzad et al., 2024).

Lam (2018) found that SSC can help companies to reduce financial risks related to the short-term stability, long-term financial profitability and survival of the company. Some scholars have raised concerns about the cost of SSC and its impact on financial returns of the company, the study found out that SSCM practices do not influence negatively on financial returns. This can be related to the fact that customers are willing to pay the extra cost of being more sustainable and that the overall benefits of sustainability overcome the increased costs at the short-term. It was also found that more complex the supply chain network of the

company is, more it can gain financial benefits from sustainability. This is important finding especially regarding many global, manufacturing companies with complex and multi-layered supply chains. (Lam, 2018) Rodríguez-González, Maldonado-Guzman and Madrid-Guijarro (2022) also found a positive link between sustainable performance and financial performance of the company in their study regarding the automotive industry. Financial performances of companies were impacted by the sustainability strategies and companies implementing sustainability practices were found to receive higher financial returns. (Rodríguez-González et al., 2022) Mann and Kaur (2020) investigated financial performances and SSCM practices utilizing data from top 100 Bombay Stock Exchange companies and found that sustainable sourcing had a significant positive impact to the financial performance.

SSC is both the expectation by the stakeholders and regulated by the regulators, but it should not be seen as an obstacle that brings extra costs to the company but as something that can bring wide range of benefits and ensure that the business can continue to grow. Company which understands the importance of sustainability invests in it since it improves the overall image of the company, which can lead to several direct and undirect benefits. (Lintukangas et al. 2016)

However, recent studies show that to companies achieve the benefits of improved supply chain sustainability, the whole supply chain level perspective must be seen and proactive collaboration utilized with supply chain members. Investing in supply chain sustainability and environmental practices is not beneficial for the suppliers if the customers are not doing the same and giving value to the sustainability efforts. (Lintukangas et al., 2023) Firms must utilize collaboration and seek win-win scenarios regarding sustainability instead of using the lowest-price as the sole indicator. Proactive sustainability strategies can lead to unique, dynamic organizational capabilities and supplier development regarding sustainability. (Kähkönen et al., 2018)

Benefit of SSC and close collaboration with supply chain members is also the improved risk management especially regarding supply disruptions and reputational damage risks (Shahzad et al., 2024). Risk management and supply chain resilience are improved when suppliers learn to identify and mitigate risks related to environmental, social and financial supply chain sustainability risks and invest in collaboration throughout the whole supply chain from downstream to upstream (Eggert & Hartmann, 2023).

Table 2 summarises the presented benefits of SSC, showing the wide range of direct and indirect benefits that companies can achieve by investing in SSC improvement.

Table 2. Sustainable supply chain benefits

Benefits	Sustainable supply chain benefits	References
1. Meeting regulatory and legislation demands.		Sandau et al. (2023); Klaschka (2017); Ortas et al. (2014); Roehrich et al. (2014)
2. Strict sustainability standards and regulations being a barrier for new competitors entering the market.		Lintukangas et al. (2023)
3. Reduction of the workers' health risks and making the working environment safer i.e. social sustainability.		Coria et al. (2022); Soni et al. (2020); Klaschka (2017)
4. Improving the environmental sustainability aspects.		Lintukangas et al. (2023); Coria et al. (2022); Soni et al. (2020); Klaschka (2017)
5. Improving the reputation and brand value of the company.		Sandau et al. (2023); Soni et al. (2020); Lintukangas et al. (2016); Ortas et al. (2014)
6. Enhancing employee, customer and other stakeholders' loyalty, satisfaction and motivation.		Sandau et al. (2023); Lintukangas et al. (2022); Ortas et al. (2014)
7. New competitive advantages, business opportunities and being a preferred business partner.		Shahzad et al. (2024); Ortas et al. (2014); Roehrich et al. (2014)
8. Securing the future business growth and expansion.		Shahzad et al. (2024); Soni et al. (2020)
9. Improved products, manufacturing and innovation processes.		Shahzad et al. (2024); Sandau et al. (2023); Soni et al. (2020); Ortas et al. (2014)
10. Improved risk management and supply chain resilience.		Shahzad et al. (2024); Eggert & Hartmann (2023)
11. Improved financial success, increased revenue, profitability and market value of the company.		Shahzad et al. (2024); Sandau et al. (2023); Rodríguez-González et al. (2022); Mann & Kaur (2020); Lam (2018); Ortas et al. (2014)

The focus on benefits coming from the SSC should always be not only at the firm-level but in three levels: company, supplier and customer as related to the concept of triple value creation (Kähkönen & Lintukangas, 2018), since this strengthens the prominence of sustainability implementation and makes all supply chain members gain benefits from the improved sustainability due to proactive supply chain collaboration.

3 METHODOLOGY

This chapter presents the information and details regarding the empirical research, which is a qualitative case study, and is conducted in the upcoming chapter 4. This chapter begins by presenting and justifying the research methodology. This is followed by presenting the case of the empirical research. The outline for data collection and content analysis method are also described. Lastly, the concepts of reliability and validity are discussed.

3.1 Research methodology

This is a qualitative case study as the empirical investigation is mainly conducted by qualitative research methods. Data of the study is mainly nonquantitative and relying on the interviews made with the several persons of the case company and from its supply chain network. (Saldana, 2011, 3–4) Qualitative research can be conducted in several industries and branches including the business and manufacturing. It can be used to study multidimensional and complex scenarios of different real-life events and recognize new insights in relation to the concepts of the study. (Saldana, 2011, 4) Additionally, the investigation utilizes some quantitative, numerical data when investigating the impact to purchasing costs if replacing SVHCs containing components with SVHC-free alternatives. This brings certain elements of mixed research methods to the study since numerical data which is usually connected to quantitative methods is utilized along with the main research methods and qualitative interview data (Östlund, Kidd, Wengström & Rowa–Dewar, 2011). This choice can be justified as qualitative research methods help to answer the main research questions and themes of the study by collecting insights from several interviewed study participants, while the investigation regarding the purchasing costs change brings quantitative and numerical evidence of the challenges the companies can face when they need to focus on improving the supply chain sustainability constantly but also making sure that the company continues to operate financially sustainable. It has been argued previously that combining the qualitative and quantitative research methods and data can be useful while answering the complex questions and phenomena, and they can support each other (Östlund et al., 2011).

Research itself is conducted by single case study. The case study can focus on persons, groups, events or organizations (Saldana, 2011, 8). In this case the focus is on the perspectives of the chosen organization, technology sector manufacturing company operating globally and being part of the complex and multilayered supply network. The case study of this investigation includes only one case example, but the case studies can also be multiple case studies including multiple different cases to understand the differences and similarities between them (Gustafsson, 2017). Single case study fits well on the purpose of this investigation as it can be usually conducted more carefully and with better precision, compared to the multiple case studies which are often very resource consuming and require lots of time and effort (Gustafsson, 2017).

The aim of the research is by discussion to compare the previous academic findings presented in the theoretical section of this thesis to the findings identified and found in the empirical section investigation at the case company. This helps to identify the most prominent and important factors presented in the previous literature and strengthen their prominence in the academic literature. Empirical investigation also helps to find potentially new factors what the case company or their supply chain network representatives identify, which were not mentioned in the theoretical section, which increases investigated the academical knowledge and information related to the topics of this thesis.

3.2 Case description

The case company of the investigation part of this thesis is a Finnish technology sector manufacturing company operating globally. The headquarters and main production facilities of the company are in Finland, but large part of the customers are foreign corporations. The company also has other production facilities globally in three different continents: Europe, Asia and North America. The company has over 450 employees globally and the annual turnover is over €60 million.

Currently the company is a facing a challenge regarding SVHCs, since they are common for instance in many electronic components. For the case company, the most significant SVHC is lead (Pb), which was listed as a SVHC in June 2018 but despite this it is still very common in many electronic components as it is used for instance in solders (Robin, 2018). Even though the amount of lead in electronic components is not usually very significant, the total

amount is still often over 0,1 % from the weight of the component, which brings REACH regulation related duties for the company such as declaring the lead containing end-products to the SCIP database and informing the customers that the products contain SVHCs. ECHA has also recommended that lead should be included in the SVHCs authorisation list, which would mean that the use of lead is banned unless the company would receive a positive authorisation decision from the European Commission, which they would need to separately apply for (ECHA, 2023).

Due to tightening regulations and stakeholder expectations the company must reduce the use of SVHCs containing components and make their end-products and the whole supply chain more sustainable. However, this process includes several barriers and challenges, what must be investigated before the company can start to reduce the use of SVHCs systematically. The process of reducing SVHCs and the outcome of improving the supply chain sustainability, can also bring benefits for the company, which must be investigated and recognized to help the company understand better how different case company and customer representatives think from the potential benefits of reducing the use of SVHCs. The investigation helps company leadership understand better the costs, barriers but also the benefits of SSC improvement, which are coming from the process of reducing SVHCs. Study results provide valuable information for all companies which are facing similar problems and increase the academic knowledge regarding the SVHCs and supply chain sustainability.

3.3 Data collection and content analysis

Majority of data analysed in qualitative research is relying on interviews made with the study participants, since interviews are usually the most effective way to acquire data from individual's perspectives and insights. Interviews can be strictly structured if certain clear, pre-determined questions are asked from the individuals or very unstructured when the interview is done by free, unstructured discussion around the topics of the study. Certain sampling strategy is usually needed before interviews, meaning the selection of interview participants, to find varying responses. (Saldana, 2011, 32–33)

To diversify responses regarding the topics of the investigation, sampling strategy was planned, which included getting research data from three levels of the supply chain: case company, suppliers and customers. To improve data sample, interviews were conducted with

different company department employees including PSM, research and development (R&D), sales, sustainability and documentation. The interviewed company employees hold different positions including the managerial positions and specialist roles. These interviews were semi-structured in nature meaning that a base of questions was used to get answers for the most important research questions and themes, but the form of interview was free discussion, and interviewees were allowed to present own insights and perspectives regarding the topics. The average duration of one interview was approximately 30 minutes and 6 different case company employees were interviewed, which 5 were face-to-face interviews and 1 by video call.

The interviews made with the suppliers and customers were more structured in nature and were conducted, except for one supplier representative interview, by sending the interviewees the interview questions by email, which included few important questions but also allowed them to express their own point of views regarding the topic freely. The two supplier corporations interviewed are important SVHCs containing electronic components suppliers of the case company with whom the company has a close relationship and mutual collaboration is active. Interviewed suppliers are a big, multinational corporations with great connections to the electronics industry and component manufacturers. These suppliers are not upstream manufacturers of the components itself but are purchasing them from several manufacturers and then supplying the components.

The six interviewed customer companies were chosen as they are important end-customers for the company, which are purchasing the end-products that currently contain SVHCs components. All interviews were made either in English or Finnish. The interviews made in Finnish were translated word-by-word into English. The interview questions framework for the case company, supplier and customer representatives is available in the appendix 1.

In addition to interview data, numerical data was utilised to investigate the impact to purchasing costs if replacing SVHCs containing components with SVHC-free options. To acquire this data, Silicon Expert database software was first used to identify potential SVHC-free components which could replace the currently used SVHCs containing components. After identifying the potential substitutive components, price information regarding these components was acquired from the suppliers' web-portals and most importantly by asking quotes from the case company supplier representatives to receive the most accurate and up-to-date price information. The yearly volume of the purchased goods was estimated based

on the case company ERP-system information, and based on this, quotes were asked from the suppliers 1 and 2 with whom the company has a close, collaborative relationship. Other suppliers were also considered but the component price information regarding them was taken from the supplier's web portals, as the company does not have as close collaborative relationship with the other component suppliers as the suppliers 1 and 2.

Details from the interviews are presented in the table 3 below.

Table 3. General interview data and details

Supply Chain Position	Company department of the interviewee	Interview method	Interview language
Case Company			
Employee 1. (Manager)	Sustainability	Face-to-face	Finnish
Employee 2. (Specialist)	Documentation	Face-to-face	English
Employee 3. (Manager)	Purchasing & Supply Management	Face-to-face	Finnish
Employee 4. (Specialist)	Purchasing & Supply Management	Face-to-face	Finnish
Employee 5. (Manager)	Sales	Video call	Finnish
Employee 6. (Manager)	Research & Development	Face-to-face	Finnish
Supplier			
Supplier 1a. Foreign Multinational Corp.	Sales	Email	Finnish
Supplier 1b. Foreign Multinational Corp.	Sustainability	Email	English
Supplier 1c. Foreign Multinational Corp.	Quality	Video call	English
Supplier 2. Foreign Multinational Corp.	Marketing / sales	Email	English
Customer			
Customer 1. Foreign Multinational Corp.	Sustainability / Eco-design	Email	English
Customer 2. Foreign Multinational Corp.	Purchasing & Supply Management	Email	English
Customer 3. Foreign Multinational Corp.	Purchasing & Supply Management	Email	English
Customer 4. Foreign Multinational Corp.	Material Planning	Email	English
Customer 5. Finnish Large Corp.	Project Management	Email	Finnish
Customer 6. Foreign Medium-sized Corp.	Sales	Email	English

The basic analysis method for this study is a content analysis, specifically a data-driven content analysis, which means that the concepts are linked to each other and the theoretical section findings are connected and compared to the empirical section interviews' findings. The aim of this is to create new academic material and answer the research questions. The content analysis is always strongly based on the author's own reasoning and interpretations, which is why it is important that the author is also making own implications and suggestions, in addition to reporting the data findings as results of the study. (Tuomi & Sarajärvi, 2018)

Content analysis is a basic tool of qualitative research, and it can be used in all kinds of qualitative investigations. However, a key principle is that firstly the data and material is carefully reviewed, classified and organized. The material of qualitative research must be structured well before it can be analysed, this is often called transcription or coding. (Tuomi & Sarajärvi, 2018) In this investigation, the face-to-face or video call interviews made were

first recorded and then transcribed, meaning that the recorded interview is converted from speech to text (Tuomi & Sarajärvi, 2018), as it increases the reliability of the analysis and makes the documentation of interview more reliable (Saldana, 2011, 39).

The analysis of the empirical section begins by presenting the answers of the interviewees related to the research questions and the themes of the study as results of the investigation. Direct quotes are utilized as they allow the reader to see exactly what the interviewees said, increasing the reliability of the research and leaving the reader with the opportunity to make own implications and conclusions. The responses from the interviewees are divided based on the supply chain role: case company, customer or supplier, and logically classified to correspond similar topics, which creates a structured flow for the presentation of the study results and makes it easier for the reader to understand the findings. The content analysis is deepened in the discussion section, where the findings of theoretical and empirical research are compared, and own implications are made.

3.4 Validity and reliability

The reliability and trustworthiness of the study should be always addressed in empirical investigations as every investigation aims to avoid errors and biases, which can reduce the reliability of the study (Tuomi & Sarajärvi, 2018). Common approach to this is by concepts of reliability and validity, which has been sometimes criticized in the field of qualitative study as these concepts have been created in the field of quantitative studies and their conceptual meanings fit better in the field of quantitative studies. However, the wording itself is not important but what matters is the context given to them. *Validity* means that the study is investigating what is promised and that the research methodology fits on the purpose of the investigation. *Reliability* is connected to the consistency of the investigation findings and results and that the study can be replicated with similar approach in the future. (Tuomi & Sarajärvi, 2018)

The reliability of this single case study is high as the research methodology has been explained to the reader, and it is possible to replicate the investigation with similar approach and find comparable results. However, certain factors such as the availability of SVHC-free components in the market are in constant change, which means that the similar investigation made in the future can lead to variations in results, but most likely to the positive direction,

i.e. the organizations have more options to reduce SVHCs and the total costs of this process including the purchasing costs can be expected to decrease. The context of the study can heavily impact to the replication of the investigation and consistency of the results. This case study is conducted in the technology sector manufacturing company, which is facing the problem of SVHCs as the substances are included in many of the components the case company is supplying from the global supply chains. Similar research conducted for example in the chemical sector company could lead to variation in results.

In terms of validity of this research, the investigation can measure what it is supposed to and is based on up-to-date evidence. The methodology fits on the purpose of the study and the diverse base for data collection in the whole supply chain level ensures that wide range of insights can be identified and compared to the previous academic literature. The insights and evidence identified from the empirical investigation are arguable good as they can be connected to the previous academic literature, which can support the findings of this research and vice versa strengthen the prominence of previous academic literature findings regarding the topics of this study.

4 EMPIRICAL RESULTS

The empirical investigation of this study is conducted in this chapter and the results presented to find answer to the research questions. The empirical part is divided into subchapters, which each focus on the sub-research questions of the thesis: (4.1) barriers the case company may face when reducing SVHCs, (4.2) impact to purchasing costs when substituting SVHCs items with SVHC-free options, and (4.4) the benefits the company may gain from improving the supply chain sustainability by reducing the use of SVHCs.

4.1 Barriers and challenges for reducing the use of SVHCs

The subchapter conducts investigation related to the barriers of reducing the use of SVHCs containing components. The main perspective of the investigation is the employees of the case company. In addition, the interviews conducted with the suppliers and customers are presented and their perspectives acknowledged, which is important to enhance the deeper understanding of the whole supply chain level.

4.1.1 Case company representatives

Both internal company level barriers and supply chain level barriers to the process of reducing SVHCs can be identified from the interviews made with the case company representatives. Key internal barriers identified are related to internal company resources and understanding the importance of reducing SVHCs comprehensively.

> *A common barrier for sustainability is that it is considered to be and also is an extra cost and the importance of it is not understood. It is not realized that sustainability is a long road and not everything must be ready instantly. The benefits are not seen when the focus is only on costs and workload.* (Employee 1.)

> *Resources and commitment within the company. Takes a lot of person hours to do this and commitment from people of different levels of organization. Even if different departments are willing to reduce SVHC, no one really knows who is responsible for*

> *this. Sustainability is definitely difficult for small companies [due to size and resources], but it could be even more difficult to bigger companies as there are so many departments and managerial levels. More cross-functional collaboration would be definitely needed, it would need to be managed and guided to make everyone know their role.* (Employee 2.)

Reducing SVHCs consumes resources from different levels and departments of the organization as mentioned by employee 2 above. Two of the most impacted departments are PSM and R&D, which was noted by the employees from both of these departments.

> *Resources are the problem both here in purchasing and other departments. Who is testing these alternatives in the R&D department. If we have to take an alternative component code for this SVHC-free component, someone has to update the product structures. In the transitional phase if we have two component codes for the component [SVHC-free and SVHC containing] we lose the volume purchasing advantage. Usually, these new regulators fall in our hands here at purchasing and we have to start solving them [which consumes resources].* (Employee 3.)

> *Some of the components we can substitute very quickly, but some critical components we start easily talking 200 or 300 hours of work per a component, which is when we run out of resources [at R&D]. Plus, the cost impact. When we have long contracts, then we must pay that cost impact for that whole remaining of contract [if the component is replaced].* (Employee 6.)

Despite this, it was recognized that the top management of the case company is giving support for sustainability improvement and understands the importance of it, which is important. However, the problem may be when the topic goes down the latter in different levels of the company, which is when the emphasis on sustainability starts to differ based on person's own perspectives and values.

> *There is support for sustainability from the top management and also from the owners, it is seen that, not only it is a must nowadays, but that sustainability can lead to improved competitive advantages and benefits.* (Employee 1.)

> *The very top management understands the importance of this, but it is not their day-to-day job, so it gets passed down to the organization and various managerial levels*

> *there is lot of misunderstanding. Not taking this seriously enough [in different departments and managerial levels] is an internal barrier.* (Employee 2.)

> *When the resources are limited, the financial situation can be hard and at some level there are still old-school thinking regarding sustainability, and it is not understood why it should be focused.* (Employee 1.)

It was also identified how increasing workload and lack of resources to pay enough attention to the regulations can become a barrier as the company has many departments but focus on sustainability or compliance is not the primary function of them.

> *If you do not have a compliance department, you are giving extra secondary activities for different departments. Like the basic job of purchasing is to purchase, but if they also need to do compliance, it is extra work.* (Employee 2.)

> *As there may not be any idea to hire new employees to handle these, all employees and different departments are then coping with these "with the left hand", as it is said.* (Employee 3.)

Additionally, it was identified how the increasing costs may become a major barrier if redesigning of products is required due to replacing current SVHCs containing components with SVHC-free options. Engineering work required for product designing causes expenses and hidden costs usually come, which may not be considered at start.

> *If you need to redesign products, they need to go through testing which costs money, and a lot of hidden costs comes from there.* (Employee 2.)

> *The challenge for us is that we have a lot of certified products and we have strict specifications on what components and materials can be used. It is a long process to change them and often it can be that, for example some recycled materials, they may not be suitable because of their technical functionalities.* (Employee 1.)

> *It seems these substances are especially related to certain types of components, which is a problem for us. For example, the diode types of components are a big grief for us. If we start to replace components which are connected to hundreds of products, it means a hundred new designs.* (Employee 6.)

This is also related to the fact that there is a lack of available SVHC-free components in the market, which increases the need for redesigning and testing if wanting to substitute current SVHCs containing components.

> *Are there suitable alternative components remains as a question, and if there are, how big work it is in the testing and component approval process. And the price of the component itself obviously and the availability.* (Employee 3.)

> *[Regarding the availability of alternatives] if we end up in a single [sole] sourcing situation then we are in problems. Even for the price of component, it usually matters most how many manufacturers there are for this component, more competition means cheaper prices.* (Employee 4.)

In overall the increasing costs of the sustainability improvements may become a major barrier as SVHC-free components tend to be more expensive and it can be difficult to transfer the price increase to the prices of end-products and companies must always remain profitable and have sufficient gross margin in the sold products.

> *In the sourcing phase we can look for alternatives and even test and approve them, to have this SVHC-free alternative ready when these get more popular. If the prices increase significantly, we can still approve this alternative [SVHC-free] component but we probably can not use it as the customer may not accept the price increase and it is not economically sustainable for us. As long as these substances are used commonly in component manufacturing, I don't see that the price of these SVHC-free components decreases much.* (Employee 3.)

> *Some of our most commonly used components include these substances, and for some, we can select alternatives without these substances, but for some reason there are components where the price change is so large.* (Employee 6.)

It is possible that certain expenses such as the increased price of components can be tried to be negotiated with the customers, but costs are also increasing in other areas when sustainability is improved. This also emphasizes the need to implement sustainability in the core values and strategies of the company. The case company's top management is giving strong support for sustainability, but as the company's journey to improve sustainability is only at the beginning, more focus should be paid to integrate sustainability in the corporate strategies.

> *Component prices should be negotiated with the customers, because we are already now negotiating if raw material prices increase due to inflation and so on. But things like investing in R&D, hiring more employees or purchasing new software it is more difficult to transfer into prices. Which is why sustainability must be part of the corporate strategy and business model that it does not always lead to increased prices. It must be unified with the current strategies instead of building a new structure.* (Employee 1.)

Employee 5 from the sales department also noted that customers are not necessarily ready to pay extra from sustainability, which is why transferring the cost of sustainability improvement in the end-products' price can be difficult.

> *In the negotiations, the customers are not ready to pay an additional price, it is assumed that the improved sustainability comes almost as a service [from where you do not need to pay extra]. The pressure to lower prices is constant and even if customers emphasize sustainability, it is still not visible much when talking about money in contract negotiations.* (Employee 5.)

Unless the customers are giving a clear emphasis to sustainability, it can be difficult to promote the importance of it in contract negotiations, especially if it comes with increased costs.

> *The topics of sustainability still come up quite little in negotiations from the customers' side. In the very latest projects, sustainability is one thing that is mentioned in the specifications as one of the factors, but how it works in practice is still a question, because these topics are quite new.* (Employee 5.)

In the supply chain level common barriers for reducing the SVHCs containing components were related to manufacturers operations and the cultural and regional aspects that the regulations are in Europe or US, but most of the manufacturers are in Asia, where similar regulations are not present.

> *In the supply chain, one of the barriers is that manufacturers of components, do not necessarily take this issue seriously or quickly enough. I think the EU and others hoped and expected that ultimately this regulation would go down in the supply chain, when top level companies are bidding for contracts, they need to comply, and then they force it down the supply chain. But at the bottom of supply chain,*

> *component manufacturers are huge companies, and they differ enormously in how transparent and quick they are to make new components.* (Employee 2.)

> *It is interesting to see how well these manufacturers [from Asia] are able to provide sustainability related information. [If the regulations aim to encourage companies to use Western manufacturers instead] it must be weighted then between the purchasing costs and sustainability advantages, risk management, logistics costs, emissions and so on.* (Employee 1.)

> *Many of the major component manufacturers are in Asia, and they are doing their best to comply with these regulations, which are coming from EU or US, but the only reason they need to comply is that their business won't suffer.* (Employee 2.)

There can also be barriers when it comes to power and leverage that the case company has on its suppliers and eventually on the upstream component manufacturers. This is related to both that it is very difficult for the case company to pressure manufacturers to develop more SVHC-free components, but also to the fact that receiving reliable data whether the components contain SVHCs or not is very difficult, if the component manufacturers and suppliers are not automatically giving that information. If the suppliers of company are not able to provide SVHCs related data, it would need to be requested directly from the manufacturers, or the suppliers must be pressured that they must provide the data.

> *If we now declare and communicate [to the customers] that we are SVHC-free, how do our suppliers keep us up to date if some raw materials change or when new substances are added to the SVHCs list if it impacts the components which we have previously considered to be SVHC-free.* (Employee 3.)

> *I think the purchasing was hoping they could get all the compliance information directly from suppliers, but now those are saying "take a look at the manufacturers' website". We would have to speak directly with the manufacturers, but we don't have all those relationships established, plus we are a small player in their standards. Or we put pressure on suppliers and point out that the legislation does apply to them and they have to provide us with REACH data.* (Employee 2.)

When it comes to barriers regarding certain specific SVHCs, the lead (Pb) is the main SVHCs related challenge at the case company and it was identified how it is hard to produce

lead-free components with equally good parameters than lead containing components have or it can at least increase the prices of components significantly.

> *One of the biggest issues is lead used in solder. According to component manufacturers, if you remove lead from solder, effectiveness of solder weakens, such as the temperatures it can be relied on. One Japanese manufacturer said that we can get rid of lead but then products suffer, and this issue has been raised for over 10 years.* (Employee 2.)

> *The component manufacturers are trying to develop SVHC-free components all the time, but can they remove these substances without the components' functionalities suffering. Even when there are lead-free alternatives, there are some other substances too which are hard to remove.* (Employee 4.)

> *If you are head of the game with this, if you are early and using SVHC-free components it can cost you more and the functionalities of components might not be as good, and your products can suffer. You definitely do not want to be behind the game, but do you really want to be head of the game either, it is about weighting the situation.* (Employee 2.)

When lead is part of items such as solder, it can be also hard to measure what is the total amount of it in the end-product level in percentages. After all, the REACH regulation limit of 0,1% of SVHC per weight of the product is not much and the limit is strict. The REACH regulation is also heavier than older RoHS directive, for instance, the solder the case company is using is RoHS free, but it could still be impacted by the REACH regulation.

> *There was a question that why we are using solder which contains lead, but the solder we are using is ultra-low lead type and there is some very, very low amount of lead in it but how do we then measure from our end-products that how much there is that lead in them when it is a part of solder.* (Employee 3.)

It was also identified how the regulator bodies are finding the situation complicated, and the manufacturers have lobbied to get exemptions as reducing lead has been found to be a major barrier or obstacle, which is why the situation has not progressed as fast as expected. However, as soon as any substance is put to the candidate list of SVHCs, it means that it is in the process of future authorization i.e. banning the use of it.

> *Manufacturers lobbied to have exemptions, but it is still a massive challenge. Redesigning is needed, if regulators ban lead and component manufacturers say that we cannot possibly make similar characteristics products unless we use lead. The legislation has been unwilling to address this issue, but that is not the issue of individual companies, it is on a much higher level.* (Employee 2.)

> *Legislation usually comes slowly, with transition times, but at some point the manufacturers have to react to it [if they want to sell to EU].* (Employee 6.)

> *It is the candidate list [for SVHC] and there is also the authorisation list [for banned SVHC]. [If lead is authorised] it would cause lot of problems for the company, but also for customers. It needs to be prepared for.* (Employee 1.)

When talking about lead it is difficult to say when ECHA includes it in the authorisation list as it is well-known how many challenges it would cause, especially in the electronics industry. However, as mentioned in the previous literature, lead has been proposed for authorisation several times and the likelihood of it being authorised is high. The question is not if, but when it happens. Surely there is a lot of lobbying and manufacturers trying to influence the regulators, as they have done earlier also, but at some point, the inevitable is bound to happen and lead is added to the authorisation list, which is when the manufacturers are forced to adapt and innovate better lead-free solutions.

However, the question is also about that all EU member countries and companies should then take these regulations and obligations seriously or it can cause inequality among the companies and give unfair advantage to those companies who can potentially ignore these regulations and therefore save internal company resources.

> *In Finland we are very precise in the sustainability matters, and in other things too such as different sanctions where we investigate very comprehensively everything even from the supplier base, but many other countries and companies [in Europe] may be less strict and they just sign some paper which states that they meet all requirements.* (Employee 3.)

This can be an issue as the enforcement of these regulations is the responsibility of each EU member country, and the level of enforcement varies a lot and how strict the legislative penalties for violating the regulations are.

4.1.2 Customer representatives

It can be identified from the interviews made with the customers that the case company can face barriers to the process of reducing SVHCs from the increasing costs. Despite the customers understanding the importance of improving sustainability, the viewpoints are more cautious if the improved sustainability is increasing costs significantly.

> *Today it is an extra cost, but sure tomorrow it is not extra cost if this kind of solutions are mandatory. For me, (sustainability department), cost is not a problem, but we have to understand all areas inside the company.* (Customer 1.)

The customer 1 response shows how different persons and departments of the company can share different opinions regarding the sustainability, which was noted at the case company level also. Even when the importance of sustainability is recognized, it may vary whether the sustainability should be given a maximum prominence if it increases the costs and could reduce the profitability in the short-term. However, the customer 1 makes an important point regarding the fact that companies should not be short sighted. Even if the costs would be higher currently, in the future the situation can turn around. Several other interviewed customers were also more cautious regarding the question of what their reaction is if improved sustainability increases the costs, which indicates that increasing costs can be a major barrier or obstacle for sustainability improvements as the customers do not want that costs increase significantly. However, as noted by Customer 3, the companies should also acknowledge and promote if the increasing costs are due to improved sustainability, as it may lead to more positive reaction towards the increased costs by the end-customers.

> *This type of awareness must be created and promoted [if improved sustainability increases the costs]. Costs and quality are always important requirements.* (Customer 3.)

> *Sustainability should go hand-in-hand with competitive prices as companies must remain profitable.* (Customer 2.)

> *Cost-competitiveness is important. The company is prepared to pay a reasonable premium for sustainability.* (Customer 5.)

> *We always assess this as an individual case. If we notice significant price differences, we check with the suppliers to see what measures can be taken to arrive at our target prices or the prices on which our calculations are based. We don't close ourselves off and only evaluate offers based on price. For us, delivery reliability, quality, delivery times and of course sustainability are factors when it comes to choosing the right supplier.* (Customer 6.)

Based on the responses, the customers value sustainability but if the improved sustainability is increasing the costs significantly the attitude towards it may get more negative and cautious, which can indicate that the case company must carry the burden of increasing costs at least partially on their own, as it cannot be transferred to the end-products prices directly.

However, some customers are also giving very strong and unconditional support for sustainability as the below response from customer 4 shows. Yet, even in that case the line "*as far as I am aware*", can hint that the thinking may not be similar when it comes to all employees. In the end, it depends on a lot how much strategic focus is given to sustainability from the top management. With customer 4, the focus is clearly significant, and major prominence is given to sustainability.

> *As far as I am aware, [The customer 4] prioritizes sustainability. To meet the challenges of sustainability, [The customer 4] has consciously decided to give eco-design a central role in its business. In 2023/24, 87% of newly developed solutions were covered by an eco-designed process, including circular economy aspects.* (Customer 4.)

Quality, costs, delivery reliability and sustainability are all important aspects for the customers, with quality and delivery reliability obviously being the main baseline for a large part of the companies. After this, costs and sustainability are assessed by their pros and cons, but according to perspectives from the case company, the costs are the major factor in contract negotiations, which customers emphasize. The strategic prominence which is given to sustainability from the top management of companies can be expected to significantly affect the decision-making, and it is likely that the company's size affects this. Global, multinational corporations have more resources and financial capabilities to invest in sustainability and handle the burden of increased costs in the short-term.

4.1.3 Supplier representatives

Barriers for reducing the use of SVHCs containing components were also identified in the interviews conducted with the important case company suppliers, which were basically connected to lack of focus on the issue of SVHCs and REACH regulations by the manufacturing and supplier base. It was recognized how the attention which is paid to reducing important SVHCs such as lead is still lacking strategic focus even from the manufacturers' side and the work is in progress with many uncertainties and questions regarding the process. The case company's own supplier 1 sales representative answered that due to lack of sufficient knowledge regarding the matter the person is unable to give comprehensive answer but noted that the importance of SVHCs is noticed and the company is processing the matter internally.

> *These questions are very interesting and relevant. We have received similar questions from one of our other customers, and we have requested for a presentation regarding lead-free options [from the internal corporation employee responsible for the related topics.], which is being prepared.* (Supplier 1a.)

The answer of supplier 1 shows that even if the supplier recognizes the importance and topicality of the SVHC issue, they may not be absolute certain how the process of reducing SVHCs such as lead works out as the work is still in progress, which is bit surprising considering that the interviewed supplier is a major, multinational corporation in the industry, and as the answer shows, other companies have asked similar questions from the supplier also. The answer from the supplier was not giving much information, other than the fact that the work is in progress, but in a large, multinational corporation it can take quite a long time before they have more information regarding the matter, which they can present to their stakeholders such as the case company of this study. Supplier 1 whole corporate level sustainability department employee was also interviewed, who is working in the headquarters of the supplier 1 company. However, the answer did not give much new information.

> *We are preparing for the proposed regulations regarding SVHC as well as all related requirements. Our current stance on SVHC is as follows: [Supplier 1] takes seriously its responsibility to ensure its businesses are in compliance with all applicable laws and regulations, including those focused on SVHCs and their impacts on the human*

> *health and the environment. [Supplier 1] complies with its obligations by informing its customers in the European Union of the presence of SVHCs in concentrations above 0.1% weight by weight in the products we distribute, where required. [Supplier 1] continuously monitors new developments relating to regulation of hazardous substances, including updates to the candidate List of SVHCs.* (Supplier 1b.)

The responses show that supplier 1 is committed to informing their customers if products contain SVHCs and monitors the development constantly, but in the future the supplier should aim to influence the manufacturers more proactively to reduce SVHCs and the issue should be considered critical for them. Positive findings were identified in the interview made with quality department employee of the supplier 1 company that the supplier company aims to do this in the future, but still in overall the supplier company responses show how currently there is a lack of strategic focus on the SVHCs reduction, and the manufacturers are even avoiding this topic as it is considered very complicated.

> *Manufacturers are rolling out lead-free versions but there is unwillingness to produce totally lead-free components as production methods are a bit different. So, they [manufacturers] are moving slow, as said the production method is different and they are also more expensive as some of these [SVHC-free] materials are quite expensive.* (Supplier 1c.)

> *For instance, in the semiconductor world, a manufacturer said the problem is a clip bonding called technic when more soldering material is needed and there is no alternative [SVHC-free] material for bonding, they are looking for alternative materials, but they have not found much.* (Supplier 1b.)

> *Not many suppliers want to discuss this, but they have to start moving to this direction, but these [SVHC-free] components are very new in the market. But we will definitely put pressure to our suppliers [the component manufacturers] that this is highlighted and needed in the market.* (Supplier 1c.)

In general, the situation that the supplier and manufacturer base is lacking focus on SVHCs reduction brings major barriers in the process of reducing SVHCs, if the suppliers are not fully prepared to this issue yet, have not paid significant strategic focus on it or are lacking the information related to the REACH regulation, which is also visible from the answers of supplier 2.

> *This is covered under the REACH SVHC framework, but as we don't manufacture products, it's not really applicable to us. Our manufacturers should each have a declaration of this on their quality pages i.e. follow this [manufacturer's] link and you can see the declaration and in this case the adoption of IPC-1752 standard for [declarable substances] reporting.* (Supplier 2.)

A major issue can be identified with this answer in the case company's perspective. Even when the supplier is not manufacturing SVHCs containing components itself, they should use their leverage and influence power on the manufacturers and pressure them to develop new SVHC-free component options. This is the only way this development towards the SVHC-free solutions can move in the supply chain and its importance understood. In addition, the suppliers are applicable to REACH regulation even if they are not the direct manufacturers of the component, since if they are importing the SVHCs containing components to EU, they are the legal entity who is placing them on the market. However, it is possible that there are issues with the internal communication on the supplier's side and not all employees have a similar knowledge of these issues, if not enough strategic focus is paid on SVHCs. Yet, these responses were given by a person who holds a director role at supplier 2 company, which is why it is surprising that the responses show a lack of awareness of the REACH regulation's obligations and demands.

Problems and barriers can also arise from the fact that there can be confusion between different regulations and their restrictions are not fully understood, which is also quite surprising.

> *The reference to lead (Pb) below, for example, was dealt with following the RoHS implementation over 15 years ago.* (Supplier 2.)

It is correct that RoHS directive also restricts the use of lead, however, several exemptions in relation to lead are given in the RoHS directive. When it comes to REACH regulation, all products which contain at least 0,1 % of any SVHC are regulated and at least the declaration obligations are applicable. The REACH regulation is heavier and stricter than the older RoHS directive has been, which emphasizes the need to develop SVHC-free solutions and focus on this issue in the whole supply chain level.

In addition, supplier 2 attached their corporate sustainability report from 2024 in the email response and investigating it verifies that the supplier corporation may not pay enough

attention to REACH, SVHCs regulations at the moment. The report does talk about reducing hazardous substances in general and mentions the RoHS compliance, but it does not mention even by single word either REACH regulation or SVHCs, which can be considered surprising and problematic as, just like supplier 1, the supplier 2 corporation is one of the world's major electronic component suppliers and distribution corporations, and the matter of SVHC is very relevant in EU region currently.

In general, the answers from both interviewed suppliers, which are by far two of the most important SVHCs containing electronic component suppliers for the case company, suggest that there can be major barriers for reducing the SVHCs containing electronic components as the supplier and manufacturing base seems to lack strategic focus on the matter, and is not fully prepared to moving into SVHC-free solutions. However, as the answers show, the prominence of SVHC matter is increasing all the time and the supplier corporations must start to pay higher focus on the matter internally. Yet, at this point the development is already behind schedule, and the higher strategic focus and emphasis on SVHC-free components should have been placed already years ago.

4.2 Operational process and purchasing costs change if substituting SVHCs components with more sustainable SVHC-free alternatives

This subchapter investigates the process of trying to reduce use of SVHCs containing components by replacing them with REACH unaffected alternatives. Previous literature identifies that increasing costs are a common barrier for supply chain sustainability improvements. Therefore, the chapter investigates the impact to purchasing costs if SVHCs containing components are substituted with SVHC-free components.

The case company has several end-products which currently include SVHCs containing components, with the most common SVHC in these components being lead (Pb). For this investigation 5 relevant and important end-products were chosen for further investigation. These chosen end-products have a long lifecycle left and they also have both actual orders from customers and forecasted need for the year 2025 and beyond, which validates that the chosen end-products are important for investigation. The selected end-products include some of the most common SVHCs containing components that the company is supplying, which means that the estimation of cost change regarding these SVHCs components and

end-products can be also compared to other SVHCs containing end-products of the company.

The end-products are named simply as end-product 1, end-product 2, end-product 3, end-product 4 and end-product 5. Currently these 5 different end-products include 23 different SVHCs containing components, and it is investigated how the purchasing costs could change if some of these components can be replaced with more sustainable SVHC-free options. Table 4 summarises the starting point of the investigation related to the process of replacing SVHCs containing components.

Table 4. SVHCs containing end-products and components

End-Products	**SVHC-components** (quantity in pcs of component in the end-product)
End-Product 1	Components **1** (1), **2** (1), **3** (5), **4** (1), **5** (1), **6** (1), **7** (1), **8** (12) & **9** (1)
End-Product 2	Components **1** (1), **3** (1), **5** (2), **6** (2), **11** (2), **12** (1), **13** (13), **14** (13), **15** (1), **16** (5) & **17** (1)
End-Product 3	Components **1** (1), **9** (2), **10** (2) & **18** (1)
End-Product 4	Components **5** (1), **10** (1), **20** (1) & **21** (1)
End-Product 5	Components **10** (1), **19** (1), **22** (1) & **23** (1)

Table 4 presents 5 different end-products from the case company and shows what SVHCs containing components each of them include. It also shows how many pieces of SVHCs components are included in the end-product. For example, End-Product 1 contains, among others, SVHC component 3 and there are 5 pcs of that component in the end-product. The SVHCs containing components were simply named as component + number, and total of 23 different SVHCs containing components were identified from these 5 end-products. These end-products are all something from where the company has made the declaration to the ECHA's SCIP database, which means the company has an accurate knowledge of what SVHCs containing components the end-products include. Silicon Expert software was used to identify potential SVHC-free substitutive components for the identified 23 components and prices for these components were requested from the suppliers of the company as per the estimated yearly volume of the purchased goods. Table 5 presents the comparison of the purchasing cost difference between the current SVHCs containing components that the

company is supplying and identified SVHC-free components which could potentially substitute the currently used components. The cheapest price for each SVHC-free component, which was received from the suppliers was selected to be presented in the table 5 for comparison.

Table 5. Price data of the investigated SVHC and SVHC-free components

Current SVHC containing component price (€ / pcs)		SVHC-free alternative component price (€ / pcs)		Purchasing cost change (%)	Component annual purchase volume (pcs)
1.	0,0275	**1.**	**N/A**	—	1 500 000
2.	0,0758	**2.**	**N/A**	—	40 000
3.	0,0684	**3.**	0,083	+ 21,35 %	100 000
4.	0,2744	**4.**	**N/A**	—	1000
5.	0,3494	**5.**	**N/A**	—	75 000
6.	0,565	**6.**	0,88	+ 55,75 %	15 000
7.	6,18	**7.**	3,69	– 40,29 %	250
8.	0,5	**8.**	0,66	+ 32,00 %	1000
9.	0,12	**9.**	0,49	+ 308,33 %	150 000
10.	0,022	**10.**	0,121	+ 450,00 %	150 000
11.	0,1525	**11.**	**N/A**	—	150 000
12.	0,0452	**12.**	0,06	+ 32,74 %	15 000
13.	0,0358	**13.**	**N/A**	—	5000
14.	0,1665	**14.**	**N/A**	—	5000
15.	3,98	**15.**	**N/A**	—	200
16.	0,225	**16.**	5,23	+ 2224,44 %	500
17.	0,10504	**17.**	0,7	+ 566,41 %	25 000
18.	0,039	**18.**	0,06	+ 53,85 %	50 000
19.	0,185	**19.**	**N/A**	—	400 000
20.	0,094	**20.**	**N/A**	—	7500
21.	0,0856	**21.**	0,1435	+ 67,64 %	100 000
22.	0,0391	**22.**	0,06	+ 53,45 %	55 000
23.	0,14205	**23.**	0,1435	+ 1,02 %	100 000

In general, the results show that choosing SVHC-free components increases the purchasing costs and in percentages (%) the cost increases can be very significant. In many of these components, the annual purchase volumes are big, which means that even when most of the components are quite cheap, the amounts can get significant due to the big purchase volumes. The results show that there is only one component where the SVHC-free component price could be cheaper than currently used SVHCs containing component. This is component 7, which costs currently 6,18 € / pcs and identified SVHC-free alternative would cost 3,69 € / pcs. However, even though this component was recommended as an alternative by Silicon Expert software, there are some differences in the specifications of these components, which means that engineering and testing work would be potentially needed if the components are switched. Another interesting finding was component 16, which is one type of connector and currently costs 0,225 € / pcs. SVHC-free alternative for

this same component from the same upstream manufacturer costs 5,23 € / pcs, about 5 € more than currently used SVHCs containing component. This is an extreme example of price difference that can be at worst between the SVHC and SVHC-free components.

N/A marked in the table means that a potential SVHC-free alternative component was not identified from the market, which was the case for 10 / 23 current SVHCs containing components. The finding shows that currently it is not possible to make any of these five investigated end-products completely SVHC-free, because there are not enough alternative SVHC-free components on the market, that match the parameters of the currently used components and are suitable SVHC-free component alternatives for the selected end-products. This finding can be considered accurate as Silicon Expert software's database, which was utilized to find for alternative SVHC-free components, includes over 15 000 component suppliers and 1 billion components (Silicon Expert, 2024), and despite this, SVHC-free options which closely match the parameters of currently used components were not identified for all parts. There are some especially problematic findings such as the component 1, which has the annual purchase volume of 1,5 million pieces and despite a dedicated effort, the SVHC-free alternative was identified for the component. For all components which contained SVHCs, and the SVHC-free alternative was not found, the problematic substance was lead (Pb). Most commonly, the lead used in solder was the issue according to component manufacturer's material declarations, but some components also lacked a material declaration or data sheet which especially mentioned where the lead is located but instead that just mentioned that the component is REACH affected.

A partial reduction of SVHCs is possible, but it does not eliminate the ultimate problem related to these substances, as companies must declare their end-products in ECHA's SCIP database and report them to customers if they contain even one component containing SVHCs. This highlights the need for manufacturers to start investing more in developing and manufacturing of SVHC-free components, especially lead-free options. On the other hand, this also emphasizes that if the case company plans to reduce SVHCs comprehensively currently, there is a significant need for product redesign and engineering work, which increases costs in many levels.

Table 6 shows the five end-products, which were investigated, showing the current SVHCs containing components that can be potentially replaced and how much it increases the costs in one unit of end-product, when the purchasing cost alone is considered.

Table 6. Purchasing cost change of the investigated end-products

End-product.	SVHC - component	Quantity (pcs)	Price (€ / pcs)	Price (€ / pcs) of SVHC-free alternative	Cost change
End-product 1.	Component 1	1	0,0275	N/A	—
	Component 2	1	0,0758	N/A	—
	Component 3	5	0,0684	0,083	+ 0,073 €
	Component 4	1	0,2744	N/A	—
	Component 5	1	0,3494	N/A	—
	Component 6	1	0,565	0,88	+ 0,315 €
	Component 7	1	6,18	3,69	− 2,49 €
	Component 8	12	0,5	0,66	+ 1,92 €
	Component 9	1	0,12	0,49	+ 0,37 €
End-product 1 total purchasing cost change:					**+ 0,188 € ≈ 19 c**
End-product 2.	Component 1	1	0,0275	N/A	—
	Component 3	1	0,0684	0,083	+ 0,0146 €
	Component 5	2	0,3494	N/A	—
	Component 6	2	0,565	0,88	+ 0,63 €
	Component 11	2	0,1525	N/A	—
	Component 12	1	0,0452	0,06	+ 0,0148 €
	Component 13	13	0,0358	N/A	—
	Component 14	13	0,1665	N/A	—
	Component 15	1	3,98	N/A	—
	Component 16	5	0,225	5,23	+ 25,025 €
	Component 17	1	0,10504	0,7	+ 0,59496 €
End-product 2 total purchasing cost change:					**+ 26,27936 € ≈ 26,3 €**
End-product 3.	Component 1	1	0,0275	N/A	—
	Component 9	2	0,12	0,49	+ 0,74 €
	Component 10	2	0,022	0,121	+ 0,198 €
	Component 18	1	0,039	0,06	+ 0,021 €
End-product 3 total purchasing cost change:					**+ 0,959 € ≈ 96 c**
End-product 4.	Component 5	1	0,3494	N/A	—
	Component 10	1	0,022	0,121	+ 0,099 €
	Component 20	1	0,094	N/A	—
	Component 21	1	0,0856	0,1435	+ 0,0579 €
End-product 4 total purchasing cost change:					**+ 0,1569 € ≈ 15,7 c**
End-product 5.	Component 10	1	0,022	0,121	+ 0,099 €
	Component 19	1	0,185	N/A	—
	Component 22	1	0,0391	0,06	+ 0,0209 €
	Component 23	1	0,14205	0,1435	+ 0,001450 €
End-product 5 total purchasing cost change:					**+ 0,12135 € ≈ 12,14 c**

At the level of one unit of end-product, findings show the cost increases are not significant in general, as the one unit of end-product usually only includes small number of SVHCs components, which is positive as it means that price changes like this can be transferred to the product prices. Obviously for some SVHCs containing components alternative was not identified, which is why the price changes can be bigger in the future when SVHC-free alternatives are available for the remaining of the components. Only in the end-product 2 price change is significant due to component 16, which brings to total purchase cost increase to over 26 €. However, there are bigger challenges than the increase in purchasing costs of one unit. Firstly, switching many of these components would require engineering, redesigning and testing work as some of the specifications can vary. Secondly, the annual purchase volumes of these components are large, which means that in the yearly level

purchasing expenses can increase significantly even when the difference is not significant in the one end-product unit level. To give few examples, when the case company is currently purchasing 150 000 pcs of component 9 annually which costs 0,12 € / pcs, amounting a total of 18 000 € annually, the SVHC-free alternative costing 0,49 € / pcs would increase the annual purchasing cost with the volume of 150 000 pcs to 73 500 €. In the component 10, the annual cost increase would go from 3 300 € to 18 150 €, and for instance in component 17 from 2 626 € to 17 500 €. In total, when considering all 13 out of the investigated 23 components for which a potential SVHC-free alternative was identified, the annual purchase cost with the same volumes would increase from 68 942 € to 170 747,5 €. Large annual cost increases like this could cause financial difficulties by influencing the budgeting and cash flow even if the customer would accept the price increase in the one component level. Thirdly, a major challenge is a lack of SVHC-free components, which means that currently it is not possibly to make any of these investigated five end-products totally SVHC-free. In overall, the increasing costs of using SVHC-free components can be identified as a noticeably barrier for the reduction process.

4.3 Summary of identified barriers for reducing the use of SVHCs

The following figure 5 summarises the presented key barriers for reducing the SVHCs and improving the supply chain sustainability, which were identified in the interviews conducted and in the investigation of purchasing cost change.

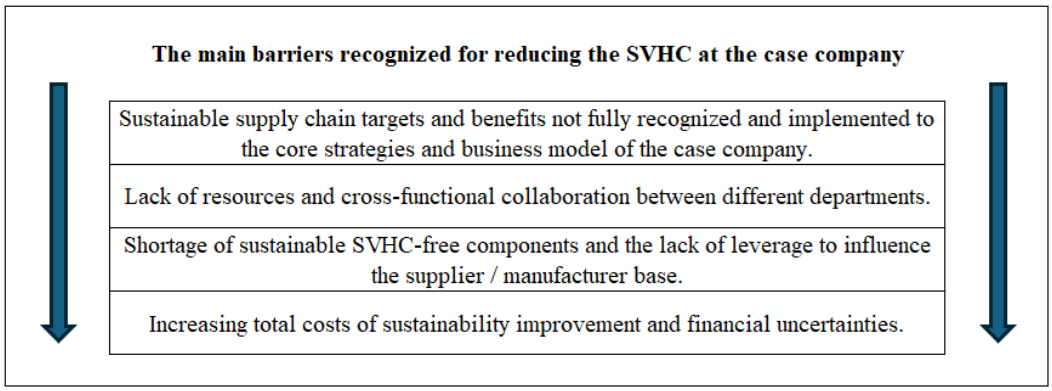

Figure 5. Identified barriers for reducing the SVHCs fall from the company's strategic level to the supply chain level

As the figure 5 points out, the different barriers for reducing the SVHCs are following each other, with all starting from the strategic level. The case company's top management is understanding the importance of sustainability improvement, but the progress is still lacking in connecting the sustainability goals and targets, such as becoming SVHC-free, to the corporate culture and strategies. The aim should be the sustainable business model, which can lead to wide range of benefits. Additionally, the lack of internal company resources was recognised as a major barrier, as the process of reducing SVHCs increases the workload in many levels of the company, whilst there are also other new sustainability related obligations, which consume resources. There can be need to hire more employees to mitigate the problem of lack of resources, while the cross-functional collaboration between different departments should be also enhanced to solve sustainability related challenges together in a close collaboration. However, this requires strategic focus on the matter and understanding of its importance. It is important that the company has sufficient strategic focus and internal collaboration regarding the sustainability matters as the supply chain level barriers for SVHCs reduction such as the lack of SVHC-free components in the market, are following internal company level barriers.

Lack of SVHC-free components was identified as the major barrier for reduction, which is why it is also worrying to notice that the supplier base is lacking progress and knowledge in relation to reducing SVHCs. Ultimately, both internal company and supply chain level barriers are increasing the total costs in many levels if the SVHCs are reduced, which also includes the purchasing costs as SVHC-free components are often more expensive than currently used SVHCs containing components. This can cause financial barriers for reducing SVHCs, as it was identified that the customers are cautious if the improved sustainability is increasing the prices, which can be especially likely if there are financial uncertainties at the company or key market regions.

4.4 The benefits of improved supply chain sustainability by reducing SVHCs

The investigation related to the benefits the case company may gain from improving the supply chain sustainability by reducing the use of SVHCs is conducted in this subchapter. The investigation presents different points of view both from the case company and customer representatives. Several benefits of improved supply chain sustainability were presented in the previous literature. This chapter presents the benefits of improved supply chain sustainability identified by the case company representatives and customers of the company.

4.4.1 Case company representatives

Employees are recognizing benefits that the case company can face if SVHCs can be reduced, and supply chain sustainability improved, which are often connected to reputational and financial aspects.

> *Things like reputational benefits, in some markets the competitors might say "we are SVHC-free", which can be a competitive advantage and help you win contracts. Risks and benefits are close, it is a risk if you do not comply. Financial is that you may lose contracts if you do not comply. But also, if you have a contract and you do not comply, it could be even worse, as you might suffer financial penalties.* (Employee 2.)

> *Reputational benefit and how improving the sustainability leads to mandatory sustainability communication, which helps customer relations, hiring new employees, and important factor which must be considered is what the customers and their customers expect and want regarding sustainability [supply chain level] benefits.* (Employee 1.)

> *How it impacts our EcoVadis and other [sustainability] classifications. The benefits it brings to us in this level, when in the image aspects we can promote that we do not use these substances.* (Employee 6.)

In general, the case company employees are recognizing that the financial benefits of improved sustainability are coming indirectly when the reputation, brand and public relations of the company are improved. It is considered less likely that direct financial

benefits could be received by increasing the prices of end-products only because they can be considered more sustainable options. Employee 1 is also presenting an important point regarding sustainability, as in the ideal situation, the outcome should never be that sustainable options are more expensive. Sustainability should be the standard, and in the future, it should be that those unsustainable options are more expensive to make.

> *I do not perhaps believe that we can make the products much more expensive and increase the prices if we are more sustainable but instead that it can increase business, improve brand and customer relationship which can support to improve sales. Of course, many companies are discussing things like ESG-premium, if sustainable products can be sold with higher price but then again, when it comes to sustainable transition and decisions, it should not be that sustainable choices are more expensive to make.* (Employee 1.)

The answers show that the reputational benefits are closely connected to financial success. If a company can improve its reputation and brand value, it should positively correlate to financial success and business growth.

The benefits of improved sustainability are also coming from meeting the customers' and other stakeholders' expectations, which helps to secure that the case company is a preferred business partner also in the future during the time when emphasis on sustainability is getting more prominent and the stakeholder demands are tightening for instance with the SVHCs. If attention is not paid to reducing SVHCs, at some point the company may lose its competitive advantage and competitors who have become SVHC-free can win the projects ahead of the companies who are still using SVHCs, which is why the case company should have a medium and long-term strategic goal of becoming SVHC-free.

> *Customers are demanding that no SVHCs at all, but still it can be requested that can we still use this because of something. But there is a very strong indication from the customers that they want to remove SVHC from their products totally. The demands may also increase and at some point, using the SVHC can be an obstacle for business. The customers are also presenting new demands regarding sustainability and circular economy aspects all the time.* (Employee 1.)

> *It is the same with our customers who say, 'we do not want you to use these substances, but if you use them, you need to declare'. But there comes a point when*

> *there can be financial penalties if you use these, and then if you do not comply you can suffer financially and certainly have reputational damage.* (Employee 2.)

> *If the customers demand that you can not use SVHCs at all [or it is an obstacle to business], but I wonder which is that company who can currently avoid using these totally. If we had the standard that we do not accept any SVHCs components, which is perhaps a utopia, we would not have to think about these problems.* (Employee 3.)

Meeting the legislative requirements is a key benefit when reducing the use of SVHCs but obviously complying with the regulations is always the expectation and not meeting the requirements can lead to sanctions and major reputational damage, which can jeopardize the future of whole company. It must be also understood that as soon as any substance is added to the SVHCs candidate list, it means it can be banned/authorized in the future. When it comes to, for example lead (Pb), the likelihood of it being banned is increasing all the time.

> *Companies are hoping to comply with the regulations, and it is beneficial, but the regulations are currently mainly about reporting duties, and not that you can't use these at all. The implication by EU is that you should stop using these substances now as we can totally ban them tomorrow. They did not outright ban them as it would throw all industries in chaos and people would lose their jobs, but this is a blacklist, "one day we will ban these".* (Employee 2.)

> *If a regulation comes and says that we can not use these substances at all then it is it, but it does not come to all substances at once, as even the RoHS restricts these but there are also lot of exemptions.* (Employee 3.)

> *Meeting regulations is a must, but because a lot of resources, work and time are spent on it, all advantages should be taken of it. Not only compliance but to maximize all benefits. A positive aspect of these new regulations is that they are guiding companies to more systematic sustainability and responsibility development, which also includes the estimation and management of risks and challenges.* (Employee 1.)

Even though some of the recognized barriers for sustainability were lack of resources and increasing costs, the clear benefits the case company can face if SVHCs are reduced can be also connected to saving resources and the work hours of employees at the case company as many of the sustainability related obligations are taking lots of resources and therefore causing costs.

> *There are also clear benefits if we can comply and we would not have to make any SCIP declarations, it saves a lot of internal work and there comes the financial benefit obviously. There are costs with the declarations and risks if we do not comply.* (Employee 2.)

> *If we can remove these substances totally, we can avoid the SCIP declarations which saves resources.* (Employee 3.)

> *We should definitely get rid of these [SVHCs]! It is so big thing and the workload is increasing all the time, the reporting obligations and such.* (Employee 6.)

> *Either we get rid of all SVHC containing components or we continue making the SCIP declarations, but with the first option we have less component alternatives and options currently.* (Employee 4.)

Previously it was identified how using more sustainable components can lead to risks and barriers if the availability of the SVHC-free components is limited to fewer number of manufacturers, which could even lead to sole sourcing scenario. However, it is also possible that in the future the availability of SVHC-free components is better than SVHCs containing components, when in the long-term the development of reducing SVHCs moves forward in the electronic components industry.

> *Most likely, the long-term component availability is better for those components which do not include SVHC. Price development, I believe that long as they [manufacturers] produce these SVHCs components they remain cheap options, but it can change when manufacturing is coming to end. It is also likely that some of these [SVHC] components just become obsolete from the market.* (Employee 6.)

The benefits related to social sustainability aspects such as the workers' safety and environmental aspects as the SVHCs are hazardous for the environment, are important to recognize and the company can do its own part in that process. However, their impact to the case company's perspective is not so significant as the amounts of SVHCs in the case company's end-products are quite small. However, it must be also recognized that even if the small components the case company is using are not particularly dangerous to workforce or environment, the bigger problems can be identified from the manufacturing process of these components, and this is also a part of the company's supply chain and material cycle, which needs to be considered when discussing the comprehensive supply chain

sustainability. Upstream manufacturing of SVHCs containing components can never be a truly sustainable process.

> *The amounts in our products are small. They are used in tiny components and are hidden away, so very unlikely it causes these harms [social and environmental sustainability] in a way we use them. There are other companies who are using very nasty substances, and perhaps the legislation was designed for more dangerous situations than ours, but still the regulation also obligates us, and it causes lot of paperwork, which is why it is beneficial to reduce these.* (Employee 2.)

> *Sustainability vice these are still substances that must be removed from the material cycles for being harmful [to the environment and social systems], that is the baseline.* (Employee 1.)

A common expectation at the case company also is that the prominence of sustainability topics such as SVHCs are only getting bigger, which is why it is beneficial to start to focus on it in advance and implement it to the core strategies of the firm as it can reduce the problems and unexpected costs in the future.

> *Slowly the biggest companies start demanding sustainability and then the requirements move down in the supply chain. In general, the automotive industry in Europe is one of the first to invest significantly in these new topics, and there sustainability already plays a significant role. It moves down to other industrial sectors also in the future.* (Employee 5.)

> *When it comes to SVHC or Carbon footprint or any sustainability topic it is speculated that should we focus on this now or later, but still, we know the regulations are getting stricter, so it is much better to start progressing now because it is much more expensive to try to put out the fires then.* (Employee 1.)

> *Everyone is using SVHC less and less, if they can, assuming that alternatives are available, our competitors are doing the same thing. The main thing is to prepare for the future.* (Employee 2.)

If the process to start reducing use of SVHCs is started now, the company may gain significant benefits in the future compared to those companies who are lagging behind in this inevitable development. On the other hand, if this issue is not focused enough, the

competitors might overtake the case company, and the risks of losing competitive advantages and not being the preferred business partner for end-customers may realize if more competitors start to become SVHC-free and promote it as an advantage.

> *This is a big challenge. It is not easy but from somewhere it must always start. We do have one competitor who claims that they are SVHC-free and even some of their product specifications or data sheets claim this.* (Employee 4.)

4.4.2 Customer representatives

The clear reputation, brand and customer satisfaction related benefits for the case company of improved supply chain sustainability by reducing the use of SVHCs can be also in identified as the customers of the case company are giving strong emphasis and value to the sustainability improvement and are seeing that the issue of SVHCs is significant.

In general, all interviewed end-customers gave strong or very strong emphasis on supply chain sustainability and saw it as a positive advantage, which can cause benefits and is considered also in the selection of business partners.

> *Sustainability is a factor, although it is not the only one and perhaps not the most important. Europe and society are pushing in this direction, our customers are pushing in this direction, the company is involved in these topics, suppliers in the same direction. At the end, supply chains must be aligned.* (Customer 1.)

> *Improving sustainability is always the target and is considered as one factor when deciding business partners such as suppliers and making deals.* (Customer 2.)

> *Improving sustainability is important. Sustainability is in quite significant role when deciding business partners. End-customer may insert clauses for sustainability and sustainability brings points benefits.* (Customer 5.)

However, even if the sustainability is considered important, it can be more difficult to measure and assess it in the globalized and complex supply chains to make sure that processes are truly sustainable, and the topic is really paid attention.

> *It is very important to advance the sustainability topic accordingly. In general, we would take this into consideration [sustainability when choosing business partners],*

> *but this is difficult to assess because we rarely have the necessary insight into the production processes of the companies or their suppliers. We unfortunately cannot check in detail how and under what circumstances a supplier abroad produces, as we are not on site. We check this with a corresponding declaration, but we cannot verify whether the suppliers adhere to the specifications.* (Customer 6.)

Especially the customers 3 and 4 brought it up strongly in their answers how sustainability is an important factor in business relationships, which proves to the case company that sustainability should be given a strategic focus to foster customer relationships and ensure the future business growth.

> *The company values improved sustainability, and sustainability is a factor when deciding business partners. All risks related to CSR of third parties are evaluated. See 'Sustainable Sourcing' that shows the parameter considered.* [The customer attached a confidential document focusing on their parametric regarding sustainable sourcing, which includes wide range of factors the customer considers, including reducing the use of hazardous items, which shows strong emphasis on supply chain sustainability.] (Customer 3.)

> *Sustainability is an important factor when choosing business partners and is valued. [The customer 4] policy consists of continuously improving the sustainability performance of its solutions by monitoring and reducing their environmental impact throughout their entire lifecycles.* (Customer 4.)

The end-customers of the case company are also recognizing and understanding the increasing regulations regarding SVHCs and are expecting that the business partners are also paying attention to these regulations, which is why it is beneficial for the case company to invest in reducing the SVHCs containing components and aim to make the end-products SVHC-free gradually.

> *Reducing SVHC is needed to meet legislation and industrial demands that obligate to reduce these substances. [The customer 2] and our supply chain partners pay attention to this development.* (Customer 2.)

> *Attention is paid to reducing SVHC and is considered important as the reduced amounts make the customer deliveries easier.* (Customer 5.)

> *In a modern and civilized world, I think it is extremely important to consider these topics [reducing the use of SVHCs]. At our company, we try to advance the topics accordingly in the development process and in coordination with our customers. As we are in a sector that hopefully continues to grow sustainably and continues to drive forward the reduction of pollutants.* (Customer 6.)

The customer 2 pays attention to legislation and industrial demands, which is important to note as a direct benefit of reducing the SVHCs is meeting the current and future legislative obligations, which can be expected to tighten. Many industries also have own lists of banned or restricted substances, which is important to be considered. Important is also to note, as mentioned by customer 5, that reducing the SVHCs makes winning the future projects easier, improve relationships with the customers and gain business advantages, as the customers are giving value to reducing these hazardous substances.

> *Reducing SVHC is considered valuable, but I think it would need to be promoted by the component manufacturer as well. [The customer 3] pays attention to two types of requirements (besides costs and quality): generic + project specific driven by homologation and end-customer needs.* [The customer 3 attached a confidential corporate sustainability document which, among other things, focused on SVHCs and mentioned that suppliers must not supply SVHCs containing components except for certain exceptions, the suppliers must provide SVHCs information transparently, declare the products to SCIP database, create a substitution plan for SVHCs and constantly monitor ECHA's updated SVHCs list.] (Customer 3.)

Customer 3 also presented important argument how the component manufacturers should pay stronger attention to reducing SVHCs, which is a very valid and important point, as currently one of the key barriers for reducing the use of SVHCs is the lack of available SVHC-free items, and the answer indicates that customer 3 has also recognized this problem. The answer shows that customer 3 has focused strongly on SVHC related regulations and is demanding that not only the suppliers comply with the regulations, but also do more than what is currently obligated by regulators. Customer 3 is a very important end-customer for the case company financially, which emphasizes the need to focus on reducing SVHCs. Customer pressure like this is a major driver of sustainability and the benefits are clear in relation to customer satisfaction, financial success and future business growth.

> *Reducing SVHC is important. Priorities set in focus on use of clean, recyclable, and natural materials. On the production side, lifecycle assessments help to identify significant environmental aspects and improvement areas and assist in the making of technical choices. On the customer side, the environmental product declarations provide a detailed picture of the impact of various company solutions.* (Customer 4.)

> *It is necessary to mitigate or decrease this kind of substances. If it is not possible to decrease them, a justification, technical for example, is requested [from the suppliers].* (Customer 1.)

Customer 4 notes that clean materials and sustainable technical choices are priorities for their company, which can be directly connected to SVHCs. Customer 1 demands that SVHCs are reduced but leaves an option for exception if it is not currently possible for some reason such as technical, which could be for instance the lack of suitable SVHC-free components. The response shows that the customer understands that the reduction of SVHCs can be complicated, but it is still something to aim for in the medium- and long-term, which is why the customer wants a justification if SVHCs are used, and with that puts pressure on stakeholders and business partners, highlighting the importance of the issue.

In general, the answers of end-customers show that they are all paying attention to sustainability and understand the need to reduce use of SVHCs. Slight differences can come from the fact how much emphasis is ultimately placed on this strategically, but the issue itself is understood and recognized by all end-customers, which means that the case company must also focus on it to remain being the preferred business partner in the future.

4.5 Summary of identified benefits of reducing the SVHCs

Figure 6 summarises the benefits of reducing SVHCs and improving supply chain sustainability from interviews conducted with the case company and customer representatives.

Figure 6. Identified main benefits for reducing SVHCs are following each other

As the arrows point out in the figure 6, the benefits of reducing SVHCs begin by the compliance to the regulations, which is the baseline for all benefits and can help to get lead over legislation, makes the preparation to the future easier and reduces risks. However, the compliance can also lead to several other benefits such as internal resources being saved if the REACH regulation related obligations such as SCIP reporting can be avoided. Reducing SVHCs can also lead to reputational advantages and improved stakeholder engagement and satisfaction as the stakeholders do value the SVHCs reduction and see it as an important topic. Improving sustainability by reducing the SVHCs can also help the company to acquire higher rankings in different sustainability assessment certifications, which improves the brand value. There are some differences in how much importance different customers give to reducing SVHCs, but a few of the case company's most important customers especially highlight the importance of SVHCs reduction, which makes it a critical topic for the company. Ultimately, this should make the improved overall sustainability and being SVHC-free a competitive advantage, which can help winning the future contracts and bring financial advantages by becoming a preferred business partner.

5 DISCUSSION

The chapter aims to link the previously identified literature findings to the findings presented in the investigation of this thesis and answer the research questions. The discussion chapter is guided by dividing it into research questions related subchapters, which starts by presenting and comparing the findings of both empirical and theoretical section regarding the barriers of improving the supply chain sustainability, which is also linked to increasing purchasing costs as it was identified in the study's investigation that SVHC-free components cost more. This is followed by a subchapter focusing on identified benefits of improved supply chain sustainability by the reduced use of SVHCs. Finally, the discussion chapter ends in a subchapter focusing on the main research question of how the process of reducing SVHCs impacts the company's operations and different departments such as PSM.

5.1 The barriers for improving supply chain sustainability

The previous literature identified both *the lack of clear sustainability regulations* (Menon & Ravi, 2021; Narayanan et al., 2019; Lintukangas et al., 2016) and *the lack of top management support for sustainability* (Menon & Ravi, 2022; Narayanan et al., 2019; Lintukangas et al., 2016) as commonly recognized barriers for improving the supply chain sustainability. The findings of this study showed that in the context of this study and a topic of reducing the SVHCs, the lack of regulations is not a barrier. The SVHCs related REACH regulation is very straightforward in EU, impacting all companies regardless of their size or industry, which instead makes the regulation a driver for sustainability implementation. However, the enforcement of these regulations may cause barriers for industrial wide implementation of SVHCs reduction, as EU member states vary in how seriously they enforce the REACH regulation and punish for violations (Schenten et al., 2020; CIRS, 2020). This was also identified in the empirical investigation when it was noted that how for instance in Finland, the companies take the sustainability matters very seriously in general, but in some other countries, more questions can be raised in how profoundly they focus on these issues.

Empirical investigation presents that in the context of the study's case company, the lack of top management support for sustainability is not a problem. Both the top management and

the owners of the company recognize and understand the importance of improving sustainability according to interviewed employees' responses. This is crucial for a successful sustainability improvement process as the top management lays down the foundation for the whole company, and it is clear, as presented by the previous literature, that in a case of lack of support from the top management, it would be a major barrier for sustainability improvement. However, the lack of understanding the benefits of sustainability can be recognized as a barrier in some levels of the organization. *Not understanding the benefits of sustainability* is also one of the most mentioned barriers for sustainability improvement by previous research (Shahzad et al., 2024; Menon & Ravi, 2022; Zehendner et al., 2021; Lintukangas et al., 2016). The study findings suggest that when the company has several managerial levels and different departments, even different production units in other countries, more misunderstanding comes, and not all employees take the issues as seriously when it gets passed down to the organization. It was also noted how there can be old-school thinking, and not all employees understand or value the effort to improve sustainability in a similar way, when only the costs and workload of the process are seen. Even if the owners of the company, or the government of a country emphasize the importance of some topic, a big part of responsibility is left to how individual people act based on their own values. This is also connected to the findings of the theoretical section of how *the company size can be a barrier for sustainability* as smaller companies may lack resources needed for the process (Lintukangas et al., 2023; Lintukangas et al., 2016). Empirical findings suggest that the company size can also be a barrier in bigger and more global companies. Even when there are more resources, the bigger companies also tend to become less agile and flexible with increasing bureaucracy and managerial levels, which causes barriers for effective sustainability implementation and decision-making.

Therefore, *the sustainability must be integrated to the core values and strategies of the firm* (Menon & Ravi, 2022; Narayanan et al., 2019) and *clear goals must be set for sustainability* (Shahzad et al., 2024; Zehendner et al., 2021), which is where the case company was identified to lack progress. This is because the journey to improve sustainability is only beginning at the case company, as the focus on sustainability is increasing in the industrial level. Findings of this study suggests that sustainability must be integrated to the corporate strategies and business model. It must be connected to current strategic goals and unified with them instead of building a new costly structure. This must also include the comprehensive estimation of risks and challenges related to the sustainability topics. Despite

there being a strong support for sustainability at the case company in general, the process of connecting the sustainability targets and goals to the corporate culture and strategies is still in transition, which can cause barriers for sustainability improvements.

Interviews also noted how the supply chain level perspectives must be considered when designing own sustainability targets. The interviews made with the customers of the case company suggest that in general all customers give strong emphasis to sustainability and reducing SVHCs, which highlights the urgency of connecting sustainability targets to the corporate strategies and culture, or there can come major barriers for sustainability improvement if the company does not have a clear direction and plan how to move forward and proceed in different sustainability topics such as the reduction of SVHCs and preparing for full CBAM and CSRD-reporting obligations after transitional period ends.

The findings of this study suggest that one of the key barriers for reducing the SVHCs and improving supply chain sustainability can be the lack of internal company resources. The previous literature also identified how *the lack of resources for purchasing and supply management* can be a major barrier for sustainability improvements (Kähkönen et al., 2018; Roehrich et al., 2014; Kähkönen & Lintukangas, 2012). Interviewed employees identified that when the resources are limited the focus tends to be on the increasing workload sustainability topics cause. It was noted how new sustainability regulations usually fall in the hands of PSM department, which increases the workload, but if the department resources do not increase the topics are handled with less priority. Commitment is required from different departments and levels of organisation, but in the operational process of substituting SVHCs containing components, two of the most impacted departments are PSM and R&D. How resource consuming replacing the components is, depends on a lot from the component itself. It was identified that some components can be replaced very quickly, but certain critical and commonly used components, it can take up to 300 hours of work to approve, test and substitute the component, which is when the resources can run out. Problems regarding the resources were also identified as many of these SVHCs components could be used even in hundreds of products. This is because the case company does not have many bulk-products, but instead the end-products are modified and designed according to customer's wishes in every project. This means that the need for redesigning can be very big, which is why the SVHCs reduction process should be started from new products.

For these reasons, it was suggested that there would be need for a compliance employee, who can control and manage the compliance side and sustainability implementation in different departments, or otherwise sustainability can be seen as extra secondary activities, and not enough resources are put on it. It was also noted that more cross-functional collaboration would be needed to solve sustainability challenges, which was also noted in the literature of how *the lack of cross-functional collaboration* can be a barrier for sustainability (Sandau et al., 2023; Kähkönen et al., 2018). Proactive and close collaboration between the PSM and R&D would be especially important in the process of reducing SVHCs. These two departments would need to work closely with sustainability and documentation, which have the most general knowledge of the regulations, and the obligations related to it. Eventually, the effort to reduce SVHCs should be also seen in the work of sales department, as they should promote the development in the process of reducing SVHCs to the customers, which can create new competitive advantages.

Despite all these mentioned barriers, findings of this study identified even a bigger barrier for reducing the SVHCs, which was the lack of available SVHC-free components. *The lack of sustainable component and material suppliers* was also recognized as a barrier for SSC in the previous literature (Shahzad et al, 2024; Menon & Ravi, 2022; Bhandari et al., 2022; Narayanan et al., 2019), with Lebeuf et al. (2024) especially identifying how the lack of SVHC-free components can be a barrier for companies. The empirical section findings regarding potential alternatives for currently used SVHCs containing components showed that for 10 out of 23 investigated components, a suitable SVHC-free alternative was not identified, despite using the Silicon Expert database software which includes over 1 billion components, and the database also included all the SVHCs components which the case company is currently using. This brings major barriers for the reduction of SVHCs containing components. Obviously, the aim was trying to identify SVHC-free alternatives which closely resemble the currently used components' parameters to make the potential replacement process less costly and resource-consuming. Perhaps with more radical redesigning and switching the current SVHCs containing components to something totally different, end-products could be made SVHC-free, but this kind of process would be very complicated, costly and resource-consuming. However, the problem which was identified in the interviews was also that the case company has many the customer certified products, and those have very strict specifications of what components and materials can be used. In addition, one customer also mentioned in the interview how the component manufacturers

should pay more attention to SVHC-free components, which indicates that they have also identified the same barrier of lack of available SVHC-free component options.

The most problematic SVHC is still lead (Pb), as it is still common in many electronic components, especially used in soldering. It was noted how the manufacturers have informed that they could remove lead, but then the functionalities of components can suffer. However, it was also noted that there are other substances too, which can be difficult to remove, and even when the development direction is that the manufacturers are trying to get rid of all hazardous substances, the question is, can it be done without the components' functionalities suffering. After all, there are many industries where it is a matter of public safety that the components are maximum resilient and reliable.

Currently there is a scarcity in the market and not enough SVHC-free components, which leads to the risk of sole sourcing situation and availability of the components which was mentioned in the interviews. This scenario must be avoided as it is increasing the supply chain resilience risks, and because less there are manufacturers, the prices tend to be higher. Which is why it was worrying to notice in the interviews made with the case company suppliers, that even they seem to be lacking the understanding of SVHCs regulations and obligations. The supplier base is behind the schedule in the focus on SVHC-free components, which causes major barriers for the reduction of SVHCs as the availability of SVHC-free components does not increase fast enough unless the suppliers prioritize this development. The interviewed suppliers are large, multinational corporations and they should use their leverage to pressure manufacturers develop more SVHC-free solutions with urgency, as the individual companies do not have enough leverage to impact the decisions of manufacturers, which is why *the lack of leverage and influencing power on the suppliers* as recognized by Lintukangas et al. (2023), Zehendner et al. (2021) and Meinlschmidt et al. (2018) can be also identified as a barrier for reducing SVHCs.

Interview responses suggested that supply chain upstream component manufacturers vary a lot in how transparent they are and how much focus they put on developing SVHC-free solutions, which causes challenges for the case company as it does not have a direct relationship with these large, global manufacturers and can not influence their actions for being a very small player in their standards. It was also noted that this kind of lack of transparency and information exchange can be a problem, because if the case company declares that a product is SVHC-free, do the supplier and manufacturer base keep the

company up to date if some raw materials or substances are changed in the manufacturing process, or when the ECHA's SVHCs list increases that the manufacturers make sure the components are still SVHC-free. Obviously, one of the barriers which was mentioned in the interviews is that many of the component manufacturers are in Asia where similar sustainability regulations are not present, and they only need to comply to not lose their business in EU. *Cultural differences and varying perspectives of sustainability* were also identified as supply chain sustainability improvement barriers in the theoretical section (Zehendner et al., 2021; Moretto et al., 2020; Meinlschmidt et al., 2018). Interviews noted that both the Asian manufacturers and EU legislators are moving quite slowly, but at some point, the manufacturers must react more strongly if they want to maintain their market shares and business in EU region. It was also noted in the theoretical section that for instance in China, the industry advisors are suggesting that the companies should adapt to EU's sustainability regulations to not lose their competitive advantages (Ng, 2024). However, interview answers also presented that perhaps the idea of these regulations is that EU is trying to support the companies use more Western manufacturers, which is when several aspects must be considered including the total costs, sustainability and availability of suitable components. At the very least, such reshoring or nearshoring moves could help companies reduce certain geographic risks and the much-talked China dependency.

Interviews suggested that the EU probably expected that these regulations would go down to the manufacturing base when the multinational corporations are bidding for contracts and they must comply with regulations, but it seems the development has been slower than expected and the lack of SVHC-free components is still a major barrier. A part of this problem is, as already mentioned in previous literature by Schenten et al. (2020), and confirmed in the empirical section interviews, the lobbying that the manufacturers and industrial organizations have done against these regulations. It was noted how this is a major problem, because both the manufacturers and legislators have been unwilling to address the issue, and by lobbying they have delayed the development, which has led to lack of innovation in SVHC-free components. Still the general expectation is that the regulations are only getting stricter and for instance the banning of lead (Pb) is getting more likely. However, the situation would be much better if these regulations had been taken seriously from the beginning, and the comprehensive process of developing SVHC-free components started. But as mentioned in the interviews, these things go much higher level than just one company, and the industrial wide pressure is required.

One of the identified barriers for supply chain sustainability improvement in the previous literature was *the lack of supply chain level collaboration* (Shahzad et al., 2024; Lintukangas et al., 2023; Zehendner et al., 2021). The lack of collaboration was not mentioned as a barrier in the empirical section interviews, however, based on the interview responses, implications can be made that the collaboration should be strengthened as it can help to mitigate many of the presented sustainability barriers. Proactive collaboration with the supplier base can help to acquire up-to-date REACH regulation related information. Additionally, it gives opportunities for the case company to influence the suppliers and manufacturers by promoting the importance of developing more SVHC-free solutions and allows the upstream supply chain partners hear the perspectives of the case company better.

Finally, the findings of this study identified that a major barrier for reducing the SVHCs and improving the supply chain sustainability is the increasing total costs which are coming from the process. Big part of previous context related research also identified *the increasing total costs* as a key barrier for supply chain sustainability improvement (Lintukangas et al., 2023; Menon & Ravi, 2022; Zehendner et al., 2021; Lintukangas et al., 2016; Narayanan et al., 2016). Interviews suggest that the main total costs increases are coming indirectly from the process of replacing currently used SVHCs containing components. It was identified how many tasks related to sourcing and R&D are increasing costs such as the testing of alternative components, and in overall, the need for redesigning. Additionally, it was noted how comprehensive sustainability improvement may require extra resources which can mean for instance hiring new employees or investing in the new software applications, but this kind of total costs increases can be difficult to transfer into prices of products.

The problems are also arising from the customers viewpoints. The interviews suggest that the customers are quite cautious if the improved sustainability is transferred to the product prices. The customers do value the sustainability and reducing the SVHCs, but in general, their responses still show that cost-effectiveness is always considered as a high priority. Few customers give very strong emphasis on sustainability, even in the case of increased costs, but even their responses show that the focus on sustainability versus cost-effectiveness can vary between different employees. The interviews made at the case company also suggest that despite the customers talking about the importance of sustainability, it is not visible much when it comes to contract negotiations and discussions about money. It seems that the expectation is that the sustainability is a must, but it should almost come as a service, which

the customer does not need to pay extra, and the case company should carry the burden of increased costs and reduced profit margins. To change this thinking, the case company should promote the importance of sustainability to customers during the contract negotiations, and in addition downstream level supply chain collaboration should be enhanced to make the companies realize that by working in co-operation and solving these challenges together the costs of sustainability can be reduced and the benefits maximized.

Direct costs increases were also identified as the investigation noted how especially in some SVHC-free components the price increases compared to SVHCs containing components can be very large in percentages, which can cause problems. The investigation of 23 SVHCs containing components proved that in general SVHC-free components cost more, as for 12 out of 13 components for which the potential SVHC-free option was found, the purchasing cost was higher than in the currently purchased SVHCs containing component. The main problem is how the price increases are in average quite big in percentages, which causes problems as the purchase volumes of the components are high, even when the price changes in one unit of end-product level are not significant in general.

The problems can also multiply when it was noted how currently the case company is saving money when purchasing components with large volumes, but in the transition phase of replacing SVHCs, the volume purchasing advantage can be lost if the company is purchasing two or more different components simultaneously. Additionally, as the company has some long-term contracts with fixed prices, if the components are switched the company must carry the burden of increased costs for the whole remaining of contract. Which is why, as mentioned earlier, it makes most sense to start the reduction of SVHCs from the new products and the contracts in bidding phase. After all, it was suggested in interviews that the sourcing can test and approve the SVHC-free components basically just-in-case, but conclusively replacing them can be difficult if the customer does not accept the potential cost increase for the time being, which seems likely based on the interview responses both from the case company and customer representatives. However, it was also noted that the company should try to negotiate the purchasing and total cost increase of using SVHC-free components by promoting the advantages, as the company is already now negotiating with the customers if component or raw material prices increase due to inflation or force majeure events such as the global pandemic. Yet, the successfulness of the negotiations can depend on a lot from the emphasis that each customer company is giving to sustainability.

5.2 The benefits of improved supply chain sustainability

On the benefits of improving supply chain sustainability *the social sustainability benefits such as improving the workers' safety* (Coria et al., 2022; Soni et al., 2020; Klaschka, 2017) and *environmental sustainability aspects* (Lintukangas et al., 2023; Coria et al., 2022; Soni et al., 2020; Klaschka, 2017) are often mentioned as they are things which are easy to recognize as clear benefits of improving sustainability. In the context of this study, reducing the use of SVHCs containing components, it was identified in the empirical interviews that these do not have as big impact since the components are very small and SVHCs amounts are not big, despite the regulations obligating the company. It was still noted that the baseline is that these hazardous substances must be removed from the material cycles, and the case company can do its own part in that process. Even when these SVHCs components do not pose a major risk for the environment or workers' safety at the case company's use, the supply chain sustainability also includes the upstream base of the supply chain, which must be considered. At the manufacturing level of these components, the environmental and social sustainability issues can pose a major risk, which must be considered as a part of comprehensive supply chain sustainability, and by reducing the use of SVHCs, the case company can do its own small part in the sustainable transition to the SVHC-free world. In general, when talking about hazardous substances, the environmental and social aspects are always a priority in the whole supply chain level as the processing of these substances is unquestionably causing problems for the environment and any living creatures.

A commonly identified benefit of SSC in the previous literature was also *the improved products, manufacturing and innovation processes* (Shahzad et al., 2024; Sandau et al., 2023; Soni et al., 2020; Ortas et al., 2014), as it was suggested how more sustainable solutions are often connected to more advanced technologies. However, in the context of this study, this claim is more controversial, as the interviews suggest that some SVHC-free components could have worse functionalities than SVHCs containing components, as manufacturers have struggled to remove certain SVHCs from the components due to their superior functionalities. For this reason, it was suggested that companies must weight which is the correct level of emphasis that is put to SVHCs reduction currently, as some SVHC-free components can be both more expensive and worse in functionalities than the SVHCs

containing components. However, the process of reducing SVHCs forces to improve innovation and product development, which can bring benefits and prepare for the future.

A key benefit recognized in the interviews of reducing the SVHCs is the compliance with the regulations and getting a lead over them. *Meeting regulatory and legislation demands* was also a commonly recognized benefit in the literature (Sandau et al., 2023; Klaschka, 2017; Ortas et al., 2014; Roehrich et al., 2014). Interviews noted that compliance is an important benefit for few reasons. Firstly, the expectation is that the regulations are getting stricter, and more substances are added to the authorisation list, meaning that they are basically banned, which is why the compliance prepares for the future. It was also suggested that more comprehensive picture should be seen and all advantages taken from the compliance. It was noted how currently the regulation obligations are mainly related to reporting duties, making SCIP database declarations and informing the customer from the existence of SVHCs in products. But even these obligations are consuming lot of internal company resources, which can be saved if there's a total compliancy. Saving internal company resources was not mentioned as a benefit of SSC in the previous literature, but in the context of this study, it was identified by several employees in the interviews, as it was noted how the workload is increasing all the time with the SCIP declarations and other obligations, and by a compliance, lots of resources can be saved when these are avoided. Additionally, interviews noted that if the company would have a clear standard that only SVHC-free components are approved, it would mean that these things would not need to be worried so much, which would be a relief in many departments including the PSM. However, even in this situation many things must be considered such as how transparently is the information passed from the manufacturer to the case company if some component materials change, which was mentioned also as a barrier for sustainability improvement and reducing SVHCs. Additionally, being SVHC-free would lead to having less component alternatives, which can increase supply risks. This would be still beneficial to prepare for the future and there should be clear long-term advantages.

Findings of this study also suggest that key benefits the case company may gain from improving the supply chain sustainability by reducing the use of SVHCs are connected to reputational and brand aspects. *Improving the reputation and brand value of the company* was recognised as an important benefit of SSC also in the theoretical literature (Sandau et al., 2023; Soni et al., 2020; Lintukangas et al., 2016; Ortas et al., 2014). Interviews suggest

that being SVHC-free can bring reputational benefits as it was identified both in the case company interviews and those made with the customers, that the customers do value the improved supply chain sustainability, reduction of SVHCs and consider it important, which brings benefits. Interviews also noted how the reputational benefit can come indirectly if sustainability classifications such as EcoVadis can be improved due to reducing the SVHCs. From the EcoVadis pillars of sustainability, the reduction of SVHCs should positively impact at least environmental, labour and sustainable procurement pillars, as the SVHCs are hazardous to both environment and workforce and the supply chain sustainability can be improved if the SVHCs containing components are not purchased. Additionally, it was suggested that improved sustainability should lead to enhanced supply chain communication with the stakeholders, which is also bringing reputational benefits and can for instance help in hiring new employees in the future as the brand image of the company is improved. *Enhancing stakeholders' loyalty, satisfaction and motivation* was also identified in the previous literature as a benefit of sustainability (Sandau et al., 2023; Lintukangas et al., 2022; Ortas et al., 2014). Sandau et al. (2023) noted how recent surveys show that especially the younger generations value that the company where they work is sustainable and purpose-driven, which shows that focusing on sustainability fosters the important stakeholder relationships and can make the company more attractive business partner and workplace.

Previous literature identified that *new competitive advantages, business opportunities and being a preferred business partner* (Shahzad et al., 2024; Sandau et al., 2023; Roehrich et al., 2014) and *securing the future business growth and expansion* (Shahzad et al., 2024; Soni et al., 2020) would be key benefits of improved supply chain sustainability, and it was also suggested at the case company that reducing the SVHCs and aiming to become SVHC-free should become an important competitive advantage, which can separate the case company from the competitors if it is promoted to the customers, and help to win contracts. It was noted at the case company interviews that customers are demanding that SVHCs must be reduced while the other sustainability demands are increasing also. The interviews made with the customers strengthen this finding, as in general all interviewed six customers emphasized how improving sustainability and reducing SVHCs are important topics. The customers also stated how sustainability is one of the observed factors in the selection of business partners. It was visible that not all customers give equally strong importance to these matters, but none of the customers said that they would not be important at all. Few very important customers for the case company also gave extremely strong importance to

the SVHCs reduction, and for instance demanded that the suppliers prepare a substitution plan for SVHCs. Expectations like this are stricter than what even the regulations currently demand, but it was already noted by Roehrich et al. (2014) how many companies are doing more than what the regulations demand to get better prepared for the future.

It was also noted at the case company interviews that a clear indication is that some customers want to remove SVHCs totally from their end-products. This increases the urgency of starting to reduce them and prepare for the future. In general, the future development direction is clear from the answers of the customers: the SVHCs must be reduced, and sustainability is a very important factor. This strengthens the finding of Soni et al. (2020) that these days any company which is aiming to expand and operate globally must understand the crucial importance of sustainability. The preparation for the future was also emphasized by several case company employees as a benefit of reducing SVHCs. It was noted how it is better to start the process now than try to put out the fires later, as the regulations and customers' demands are inevitably getting stricter. It was suggested that the importance of sustainability increases all the time when bigger corporations start to demand it from their suppliers, and sustainability is already very important in key European industries such as the automotive industry. This is likely as even new regulations such as EU's Supply Chain Act demand that large corporations focus on the sustainability of their whole supply chain (EQS Group, 2024). Because of this, it was noted that probably all corporations are starting to put varying focus on SVHCs reduction and if this is not focused, the case company could end up losing business in the future. The case company already now has one competitor who claims to be SVHC-free, and this is a competitive advantage they can use, if the claim is correct and verified.

Improved risk management and supply chain resilience was also recognized as a benefit of sustainability in previous literature (Shahzad et al., 2024; Eggert & Hartmann, 2023). The case company employees also noted that if sustainability is ignored the company faces a risk of reputational and financial damage as the customers can avoid unsustainable partners and, in the future, there could be financial penalties for using the SVHCs. Therefore, the risk management especially in relation to reputational and financial risks can improve if SVHCs are reduced. It was also noted that in the long-term it can be expected that the availability of SVHC-free components is better, and some of the current SVHCs containing components can get obsolete from the market when their lifecycle is coming to end. SVHC-free

components tend to be newer, which should mean that their remaining lifecycle is longer, and therefore using them could reduce the risks on supply chain resilience. However, currently it can also be that certain risks could increase by using SVHC-free options as there are less manufacturers for those components, which could lead to the sole sourcing situation.

Finally, the investigation findings suggest that by reducing the SVHCs and aiming for SSC, the case company may gain financial advantages in the future. *Improved financial success, increased revenue, profitability and market value* was also identified in the previous literature as a positive outcome of improving the supply chain sustainability (Shahzad et al., 2024; Sandau et al., 2023; Rodríguez-González et al., 2022; Mann & Kaur, 2020; Lam, 2018; Ortas et al., 2014). The financial impact of improving sustainability has been investigated a lot as the general expectation in many companies, and by some scholars, has been that sustainability is a burden, which only increases costs and harms the profitability of the company. However, the previous research does not back up this hypothesis and instead the findings suggest that sustainability can bring financial benefits in the medium- and long-term even if it increases the expenses in the short-term.

Interviews also suggest that the case company can gain financial advantages as a result of improved company reputation, which can lead to increase in sales and winning more contracts. It was not considered that the prices of end-products can be significantly increased just because they would be more sustainable, which is also backed by the customer interviews who seemed to be more cautious if the sustainability leads to significant increase in end-product prices, but instead the financial advantages should come indirectly from the improved brand value and reputation. It was also noted that even when some companies are discussing things like ESG-premium, the general idea of sustainability should not be that unsustainable solutions are cheaper.

The biggest global corporations and market leaders in many sectors are already now putting most comprehensive focus on sustainability (Roehrich et al., 2014), which is also because they face the biggest stakeholder pressure for sustainability, but additionally also shows that sustainability and competitiveness can be connected and advantages gained from it.

5.3 The impact of reducing SVHCs to PSM and overall company operations

The discussion chapter ends by answering the main research question of this thesis, which was *how does the reduction of SVHCs affect purchasing and supply management and overall company operations?* To answer this question, implications and suggestions are presented based on the findings of this study and previous literature and it is discussed how the company operations and different departments in general, are impacted from this process of reducing the use of SVHCs.

It can be summarized that the impact of reducing SVHCs to company's operations is coming from the identified barriers and benefits of the process of reducing SVHCs itself and what implications can be made from this. Firstly, it was identified how the lack of resources is an important barrier in the process of improving supply chain sustainability by reducing SVHCs. The process of reducing SVHCs, brings extra work and consumes resources from several departments of the company, most importantly PSM and R&D. This can have negative impact to the performance of different departments if the workload increases, but the resources remain the same than earlier. For this reason, it was also suggested that the company could benefit from a compliance employee who is focusing on different sustainability and legal compliance related matters as currently these kinds of topics are not the priority number one in any department, which must focus on their day-to-day operational work to keep the basic functions of the company running. However, reducing SVHCs can also have positive impact to the company's operations when it comes to resources as the reporting obligations can be avoided if the company can become SVHC-free, which are currently consuming lot of resources. It must be noted that several different sustainability obligations are increasing and many of them, such as CSRD-reporting, can not be avoided. Yet, the obligations of REACH regulation are one of those which can be avoided if the company just does not use SVHCs. The compliance should also lead to standard that only SVHC-free components are accepted which would ease the pressure from sustainability in many departments and reduce future risks and challenges. If in the future, any substance that the company is using is added to the REACH authorisation list, and the company would still need to continue using it, it would require a very long, bureaucratic and costly process of seeking the positive authorisation decision from the European Commission, which would consume enormously resources and cause financial expenses.

Reducing SVHCs can also have major impact to the operations of PSM department. Firstly, the PSM must strengthen and improve the collaboration in the supply chain with both the first-tier suppliers and upstream manufacturer base to access the REACH related information and find more SVHC-free component alternatives. It is one of the tasks for the PSM to attempt influence the suppliers proactively to invest in SVHC-free solutions and promote the importance of it. Worrying finding was that the supplier and manufacturer base is lacking the development in relation to SVHC-free transition and are not fully prepared to it in the strategical level, which requires deeper collaboration and aiming to increase the leverage over the suppliers and foster supplier relationships to perhaps create some new dynamic capabilities. Obviously, the industrial wide pressure is needed but the case company can do its own part in it and not underestimate their own potential impact. Additionally, it can be worth considering for the PSM the geographical location of the manufacturers. It is possible that currently for instance the manufacturers from Western countries, US and Europe, can have more advanced SVHC-free solutions than the manufacturers from Asia, as the sustainability regulations in Western countries are stricter. However, it must be also recognised that even currently many of the component manufacturers could be for instance multinational US corporations, but still their production units where the components are produced are in Southeast Asia. The presented suggestions can also have a positive impact to reducing the risks of sole sourcing situations where the company unwillingly ends in a situation that there is only one manufacturer for a certain component. Additionally, utilizing new technological and AI solutions such as the different sustainability and SCM related software can help to mitigate different risks and work as new useful tools for PSM employees. For example, the Silicon Expert software which was used in this thesis investigation can help to identify more SVHC-free components and their manufacturers. However, the licence costs of these new software can also increase financial burden and impact the company negatively, which is why the benefits and costs must be weighted as in any topic. New sustainability obligations are especially influencing the PSM department, as usually the new obligations focus on the whole supply chain level sustainability and not just the individual company level. This makes it important to start adjusting to them now, which makes the future less risky and makes the planning of it easier.

Along with the PSM, the R&D department also has a crucial role in the SVHCs reduction process as lots of engineering, testing and redesigning work is connected to the process of reducing SVHCs. Even more currently when the investigation proves that there is lack of

available SVHC-free components, and the suppliers do not have sufficient strategic focus on the SVHC-free components currently. Due to this, it was also identified how currently it is not possible to make any of the investigated five end-products totally SVHC-free, which raises questions that is the partial reduction sensible, as it does not remove the actual problem totally, which is the obligation for SCIP database declarations and informing the customers that the products contain SVHCs. To mitigate these negative impacts, the SVHCs reduction process must be started gradually, and it should be started from the new products. When designing and developing new products, the aim should be that all SVHCs containing components must be avoided if possible. Most of the case company's products are designed per customer's needs in each project, which gives opportunities to develop new SVHC-free products when a new project is starting. Gradually, older products can be also redesigned to become SVHC-free when the availability of SVHC-free components increases, and the supplier base starts to pay more attention to the topic. Obviously, the R&D department is also negatively impacted from the increased workload, expenses and lack of resources, which can slow the SVHC-free transition. In general, the SVHCs reduction should lead to improved innovation and help to develop more sustainable products. This is important as currently one of the negative impacts of reducing SVHCs can be that not all SVHC-free components match the functionalities of currently used SVHCs containing components, which could even lead to decreased product reliability and quality.

Eventually the process of reducing SVHCs impacts comprehensively all company functions and operations, which means that the sales department must also do their part of SVHCs reduction process. The role becomes important in the contract negotiations with the customers as the case company must promote improved sustainability, such as being SVHC-free, to the customers to make it a competitive advantage. Improving sustainability does not bring benefits if it is not promoted to the customers that they can know it. After all it was recognised that the customers do value improved sustainability and consider it important, which indicates that sustainability related competitive advantages could compensate even the slightly more expensive prices. Being SVHC-free can be a factor that helps to win the contract ahead of a competitor who can be bit cheaper, but not SVHC-free. One problem clearly is that SVHC-free components tend to be more expensive than currently used SVHCs containing components, however, it is possible that these kinds of price increases could be negotiated with the customers when the benefits are promoted. After all, the component price increase negotiations are not uncommon in recent years when there have been force majeure

events such as the Covid-19 pandemic which led to increasing inflation, and the prices were negotiated with the customers. The difference just is that if the price increase is due to improved sustainability, it can also bring overall benefits to the customer. It could be even said that if the customer does not understand the importance of improved supply chain sustainability, it can cause critical risks for their company also in the future. Especially when talking about large corporations, the large corporations are facing increasing regulations such as EU's Supply Chain Act, which obligates, with the threat of sanctions, to analyse the supply chain sustainability of the corporation and improve it systematically.

At the whole company level, the process of reducing SVHCs also impacts the company operations comprehensively. There is a need to change the thinking regarding to sustainability and understand how it is a long process which must be integrated to the company functions and strategies. The top management and owners of the company are understanding the importance of sustainability topics, which is visible also from the fact that a sustainability manager was hired at the company earlier in 2024, which the company did not previously have. However, because of this, the comprehensive sustainability implementation is still at the early stages and there is a need to set clear sustainability targets, such as becoming SVHC-free, implement them to the strategy and aim for a sustainable business model. As the lack of resources can cause negative impact to the company, when many different sustainability obligations are coming at the same time, there is a need to combine resources cross-functionally and enhance the internal collaboration. In the context of SVHCs reduction, the collaboration between PSM, R&D and production is especially important, but as presented above, the process of reducing SVHC and promoting the benefits of improved sustainability to the customers requires effort from many different departments including the sales, marketing, sustainability and even documentation.

The interview results showed that customers are likely to be cautious if the improved sustainability is increasing the prices of end-products as many of the customers emphasized cost-competitiveness, and the case company interviews also noted how the pressure to lower prices is constant. However, the answers also show that customers do value the improved sustainability, SVHCs reduction and consider it important and a key factor in the business partner selection process, which shows that if the sustainability is not focused the business can suffer in the future when the legislation and stakeholder demands for sustainability keep increasing. As mentioned by Zehendner et al. (2021) these kinds of paradoxes are often

connected to sustainability improvements, and they are common to cause tensions, which is why a proper balance between sustainability and cost-effectiveness must be found. For this reason, it is also important to connect the sustainability to the business model and set clear targets and strategies for it. This is also important as the case company must start the sustainability communication as a part of EU's CSRD-reporting, but it is very difficult to report from sustainability if there are no concrete actions made and a clear path for the future. Not everything must be done instantly, but there must be a clear roadmap for the future.

Despite all this, there can be a negative impact to the case company if the customers keep demanding the prices must be lowered, or they refuse to negotiate, while also demanding that sustainability must be improved constantly. New sustainability obligations are inevitably increasing workload, which increases expenses and for instance the SVHC-free components also tend to be more expensive. In addition, becoming SVHC-free requires redesigning of products and testing of alternative components, which also increases the total costs of the process, and clearly a part of this total cost increase would need to be transferred to the product prices to keep the business economically sustainable. Which is why the collaboration with the customers must be strengthened and the benefits of sustainability promoted to make being SVHC-free a separating competitive advantage, which would be an important goal in the whole supply chain level as it can bring benefits to the whole downstream supply chain from the case company to the customers and their customers.

However, even when the study results show that SVHC-free components cost more than currently used SVHCs containing components, the purchasing cost differences are not so large monetary in one end-product level in the investigated 5 end-products than they are in percentages. Obviously, when talking about other end-products than those investigated in this thesis, the price impact must be examined case-by-case, but as the investigated components were some of the most common SVHCs containing components the case company is using, and none of the end-products generally contain that many of SVHCs components in pieces, it can be expected that the financial impact to the company is similar in other end-products too. As always, the total costs must be considered and not only the purchasing cost, which is only a small part of all expenses.

Still, this gives opportunities for financial advantages for the case company if the total cost increase can be at least partially transferred to the end-product prices and then for instance the SVHC-free components become cheaper. It can be considered more likely that in the

future the price of SVHC-free components decreases when the alternatives in market increase, and the legislation gets stricter which forces manufacturers to focus more on SVHC-free components. Unlike with SVHCs containing components with it can be expected that their price could only increase in the future when the legislation becomes stricter and there could also be financial penalties for using these components. To give example from the investigation, the investigated SVHCs containing component 9 currently costs 0,12 € while the identified SVHC-free alternative for the same component would cost 0,49 €, a significant price increase of over 300 %. However, at the product level, in terms of money, the investigated end-product 3 for instance includes two pcs of component 9 and three other SVHCs containing components, making the total price increase in one unit of end-product level to 0,96 €. If it can be negotiated with the customer that they accept some quite small price increase in the one end-product level, which is coming from this purchasing cost increase of 0,96 € and additional costs of the process, and then the price of component 9 would for example decrease from 0,49 € to 0,35 €, the case company could get the annual profit and saving of up to 21 000 € with the same annual purchase volume of 150 000 pcs, as per the simplified calculation: *(0,49 € x 150 000) – (0,35 € x 150 000) = 21 000 €.* However, many factors can influence the potential price development of components including the estimated lifecycle which is remaining and how many upstream component manufacturers there are, which is why predicting the price development can be a risk. Yet, in general it can be estimated that there is more room for the future price reduction in the category of SVHC-free components than in many of the currently used SVHCs containing components, which may have already reached their lowest price point for being in the market longer periods of time and having many upstream manufacturers.

The company can still face negative financial impact from the SVHCs reduction as the purchase volumes of components are large. The investigation proved that for some components the annual price increase can be even tens of thousands of euros. Such large price increases can impact budgeting, cash flow and working capital needs even if the customer would accept the price increase in the end-product level, and there could be potential need for different financing measures such as invoice factoring to balance the situation and keep the cash flow at healthy level.

The process of reducing SVHCs consumes lot of resources and can bring negative financial impact to the company in the short-term and increase the financial burdens, which is why a

balance must be found between improved sustainability and cost-competitiveness. In the medium- and long-term the improved supply chain sustainability by reducing the use of SVHCs should lead to improved company reputation, which can bring financial benefits such as increase in sales and help to win more contracts when the company is a preferred business partner for the customers. Full compliance with the regulations also means that internal company resources are saved and the risks of potential non-compliance penalties either from the regulatory bodies or customers are avoided. Figure 7 summarises the presented answers to the main research question, and implications and suggestions made.

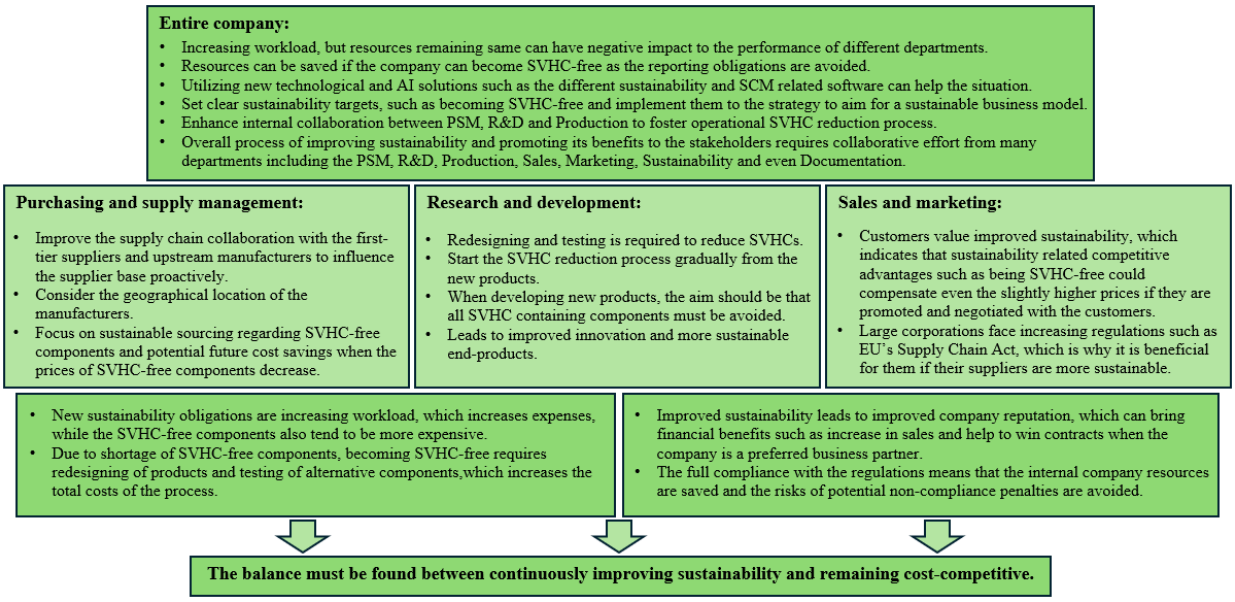

Figure 7. Summary of main research question findings and implications made

Process of reducing SVHCs impacts almost all departments of the company, which must work together in a close internal collaboration. The process is a big challenge, but at some point, it must be begun and start progressing gradually by balancing the cost-effectiveness, product quality and the speed of SVHCs reduction.

6 CONCLUSIONS

The key identified barriers companies may face regarding the SVHCs reduction are related to the lack of internal company resources, increasing total costs of the process and most importantly the lack of available SVHC-free components currently. However, it is beneficial to progress the matter and reduce SVHCs gradually as it helps to prepare for the future and stricter regulations by getting lead over legislation, which can also ease pressure and save resources from several departments regarding SVHCs if the reporting obligations in relation to these substances can be avoided. This should also lead to improved company reputation and brand value which can bring medium- and long-term financial advantages. The process impacts several departments of the company cross-functionally and short-term negative effects such as increased costs are common, but the future benefits are also clear and these days not focusing on sustainability topics can even jeopardize the future of the whole company. Many of the benefits which can be gained by reducing SVHCs such as improved company reputation and financial advantages can also turn into risks if the SVHCs reduction is not focused, as it can lead to decreased stakeholder satisfaction, weakened company reputation and financial risks of non-compliance penalties in the future.

The SVHCs reduction in the supply chain level requires collaborative approach as no company can do it on their own. As per the triple value creation, a successful SVHCs reduction can bring benefits to all supply chain partners focused on this study: *Company* by being the preferred business partner, improving company reputation, and complying with the legislation. *Customers* by improving their own overall sustainability if their suppliers are more sustainable. Especially when talking about large multinational corporations, it is very beneficial for them if their suppliers are sustainable as the large corporations in EU are facing more pressure from the stakeholders and new regulations such as the EU's Supply Chain Act, which requires that large corporations identify and mitigate sustainability risks from their supply chains. And for *suppliers* by becoming a preferred component supplier leading to competitive advantages among other suppliers in the market. This creates a collaborative circle where all supply chain partners have incentives to focus on improving sustainability as it can lead to financial advantages, and those supply chain players who remain unsustainable end up losing their business.

As every sustainability topic, reducing SVHCs is a long road and not everything must be ready instantly, but the process must be started. Reducing SVHCs must be done gradually and combined with other sustainability obligations which are increasing such as CBAM and CSRD. This leads to sustainable business model and sustainability being a part of corporate strategy, which is when it does not always lead to increased prices and negative effects but to benefits and competitive advantages.

The process of reducing SVHCs, or investing in any other sustainability topics, while also remaining cost-competitive in the global market is not easy. Western companies can not compete by the lowest cost versus the companies in Southeast Asia or other emerging markets, which is why it is crucial to find competitive advantages from other things such as sustainability. Not to mention other important themes such as AI which can be also connected to sustainable business and economic growth.

It must be noted that all major business regions in the world are investing more or less to sustainability topics such as green transition and circular economy, which is why it is critical for EU to become the leader of sustainable business, which is connected to digitalization, AI and constant innovations. For instance, currently Chinese manufacturing companies can compete by price versus the Western companies, which brings them competitive advantages, but there are also increasing sustainability regulations in China, and they are also aiming to make sustainability a beneficial factor for business growth. This means that if the Western companies do not focus on improving the sustainability and connecting it to innovations and technology development, the situation in the future can be that Chinese companies are still cheaper options while also being sustainable and the Western companies are left behind in the development. For this reason, it would extremely important that the customers understand that there must be collaboration to carry the burden of negative effects of sustainability improvement to achieve maximum benefits. If the customers keep demanding that the suppliers must be more sustainable but also cheaper all the time, the negative effects can just multiply. The supply chain level collaboration and working together to solve these challenges is much more beneficial for all supply chain partners than each company trying to mitigate them alone.

The history of industrialization has examples of how even very successful corporations have collapsed if they have made strategic mistakes, failed to innovate and adapt to the key market movements, trends or regulatory changes. Previous literature also noted that if companies

want to survive, they must adjust to the main themes of each era, with one of the main themes of the current era clearly being sustainability.

The world is witnessing the times of global competition: economic and political. Deep down it is also a question of strengthening the EU as a market region and investing in economic growth and opportunities in the region. Decision to use Western manufacturer should be the most sustainable high-technology solution, and in overall, the most beneficial micro- and macroeconomically to secure the economic growth and high competitiveness for the companies in EU region also in the future.

6.1 Limitations and suggestions for future research

While this study provides valuable insights to the topic of reducing SVHCs, it is important to acknowledge that there can be certain context specific limitations regarding the investigation, which is a single case study at a technology sector manufacturing company operating globally. The generalisation of these results can be harder in a different study context as especially the barriers for the process of reducing SVHCs can vary depending on the context of the investigated company and its progress in the sustainability matters, while it can be considered that the benefits of improving supply chain sustainability are more universal in different contexts. It can be also considered that the availability of SVHC-free components is improving which can lead to variation in findings in the similar investigations in the future, but to the positive direction regarding the options for SVHCs reduction.

The key findings of this study can be still generalised to represent the common barriers, benefits and the overall impact the companies face when reducing the use of SVHCs. Few suggestions for future research are also presented. The component manufacturer level investigation on the process of developing SVHC-free components could be conducted to gain insights from the upstream, supplier base of SVHCs reduction. Multiple case study of the similar topic than in this study could bring insights from different companies and sectors to strengthen the findings. It would be also important to investigate the medium- and long-term impact to the corporations who have either ignored or paid strong attention the sustainability topics to gain more insights regarding the justification and benefits of supply chain sustainability improvement.

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Appendix 1. Interview questions

Case company representatives:

1. What barriers and challenges the company may face when reducing the use of SVHCs?
2. What are the potential benefits of improved supply chain sustainability by reducing the use of SVHCs?
3. What other positive advantages the company may gain from reducing the use of SVHCs?
4. What is the overall impact to company's operations especially thinking your own role and department when the SVHCs are reduced?

Optional other comments regarding the topic:

Customer representatives:

1. Does your company value the improved overall sustainability and see it as an advantage?
2. Is sustainability an important factor when deciding your business partners?
3. What is your primary reaction if the improved sustainability comes with extra cost?
4. Do you consider it beneficial to reduce use of Substances of Very High Concern and why?

Optional other comments regarding the topic:

Supplier representatives:

1. Have you recognized the need to reduce use of Substances of Very High Concern in components and items you supply?
2. What challenges and barriers you recognize there are in the process of reducing use of SVHCs?
3. Is it difficult to find or produce SVHC-free options for replacing components which include SVHCs currently?
4. If SVHC-free items are currently more expensive than SVHCs containing items, do you consider that this can change in the future due to tightening legislation and regulations?

Optional other comments regarding the topic: