University of Tartu

Faculty of Social Science

School of Economics and Business Administration

Fan Zhang

Reconfiguration of Semiconductor Supply Chain in Estonia

Master Thesis

Supervisors:

Urmas Varblane

Mathias Juust

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Name and signature of supervisor…….
Allowed for defence on.....

I have written this Master Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

..... (Signature of the author and date)

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Abstract

This thesis aims to investigate the changes in the semiconductor supply chain in Estonia to see if there has been reconfiguration in the past four years (2018 to 2021). This thesis examined the trade flow of semiconductor in Estonia, which showed that the overall changes of semiconductor supply chain in Estonia reconfigured from Europe to Asia, from Northeast Asian countries and regions like China, Japan, Taiwan (CN) and South Korea to LLCs (Low-Cost Countries) in Southeast Asia like Malaysia and Philippines. Semi-structured interviews with the managers in the electronic manufacturing industry are conducted to provide managerial insights regarding semiconductor supply chain in Estonia. The results show that the current semiconductor supply chain structure does not fulfill the need for electronic manufacturing companies in Estonia. High value-adding companies like OBM (Original Design Manufacturer) companies have to choose resilience over cost. Low value-adding companies like EMS (Electronic Manufacturing Service) companies have to choose cost over resilience. Geopolitical issues intensify the semiconductor supply chain instability. The findings provide managerial implications for companies who work with semiconductor supply chain in Estonia.

Pooljuhtide tarneahela ümberseadistamine Eestis

Käesoleva lõputöö eesmärk on uurida muutusi Eesti pooljuhtide tarneahelas, et näha, kas viimase nelja aasta jooksul (2018-2021) on toimunud rekonfigureerimisi. Käesolevas lõputöös vaadeldi pooljuhtide kaubavoogusid Eestis, mis näitasid, et pooljuhtide tarneahela üldised muutused Eestis konfigureeriti ümber Euroopast Aasiasse,

Kirde-Aasia riikidest ja regioonidest nagu Hiina, Jaapan, Taiwan (CN) ja Lõuna-Koreast odavate kuludega riikidesse Kagu-Aasias, nagu Malaisia ja Filipiinid. Elektroonikatööstuse juhtidega korraldati poolstruktureeritud intervjuud, et anda juhtimisalane ülevaade pooljuhtide tarneahelast Eestis. Tulemused näitavad, et praegune pooljuhtide tarneahela struktuur ei rahulda elektroonikatootjate vajadusi Eestis. Kõrget lisandväärtust loovad ettevõtted nagu *Original Design Manufacturer* (OBM originaalse disaini tootja) ettevõtted eelistavad vastupidavust hinnale. Madala lisandväärtusega ettevõtted nagu *Electronic Manufacturing Service* (EMS) peavad valima odava hinna vastupidavuse asemel. Geopoliitilised probleemid intensiivistavad pooljuhtide tarneahela ebastabiilsust. Tulemused mõjutavad juhtimisalaseid ettevõtteid, kes töötavad Eestis pooljuhtide tarneahelaga.

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1. Introduction

With the globalization of the world's economy and product diversity, companies collaborate in the supply chain to gain mutual benefits (Simatupang et al., 2002). However, those supply chains are exposed to external economic factors that cause instability in the way they operate. In recent years, several major events that shook the foundation of the familiar world have had a massive impact on global economy. With the China-US trade war in 2018 and the COVID-19 pandemic in 2020, many companies face challenges in the supply chain, which will reconfigure the future of the supply chain (Handfield et al., 2020). Among this trade turbulence, the semiconductor industry is particularly impacted due to geopolitical reason, mainly for policymakers in the West targets the semiconductor supply chain to safeguard the critical infrastructure in the telecommunications sector (Bown, 2020).

With more than 250 companies and 12,000 employees, the electronics industry is one of the largest industrial sectors in Estonia with significant contribution to the GDP. In the year of 2021, electronic manufacturing industry contributed 2 billion turnover (*Smart Electronics from Estonia*). In the same year, the total value of semiconductor importing in Estonia is 71,811,298 Euros (Statistics Estonia Database). However, one article from Deloitte (*My Kingdom for a Chip*, n.d.) predicts that many types of chips will still be in short supply throughout 2022, and with some component lead times pushing into 2023. Estonia is no exception to this semiconductor shortage. The major electronic manufacturing companies in Estonia, namely Ericsson Eesti AS, Enics Eesti AS, Eolane Tallinn etc. have all been facing challenges in semiconductor supply chain.

This thesis contributes to the literature by focusing on the semiconductor supply chain in Estonia. Kiisler et al., (2020) found that the biggest challenge of supply chain in Estonia is the difficulties of forecasting demand. As China is the biggest exporting country of semiconductor to Estonia since 2019 (Statistics Estonia Database), the geopolitical issue

has made the supply chain more unstable (Bown, 2020). Therefore, investigating the semiconductor supply chain in Estonia is an unique chance to explore one of the most critical raw material (Voas et al., 2021) in one the most open economies in the world (Pank, 2022).

Yet the semiconductor supply chain in Estonia has not been studied in the academia. However, according to the statistics gathered from Statistics Estonia, it is evident that the processes resembling the reconfiguration of supply chain took place in Estonian market within the last 4 years from 2018 to 2021. This thesis will study what the changes have been in the semiconductor supply chain and what are the causes of these changes.

Thus, this thesis's research proposition is that there is a reconfiguration of the semiconductor supply chain in Estonia, which is that it reconfigured from Europe to Asia, from Northeast Asian countries and regions like China, Japan, Taiwan (CN) and South Korea to LLCs (Low-Cost Countries) in Southeast Asia like Malaysia and Philippines.

This thesis will focus on whether there is a reconfiguration of semiconductor supply chain in Estonia; what are the factors that contributed these changes; what could be the done in business to migrate the potential influences. To achieve the objectives, several tasks shall be done:

- Literature review of previous works related semiconductor supply chain in Estonia.
- Descriptive analysis of the trade data of semiconductor importing in Estonia. Illustrate the changes of trade flow.
- Construct semi-structured interviews with the managers in the electronic manufacturing industry.
- Compare the findings from interviews and the qualitative analysis from trade data.
- Conclude by providing relevance from challenges from each category and business implications for managers in the industry.

The empirical part of this thesis applies the semi-structured interviews with the managers in the electronics manufacturing industry. Answers from the interviews are organized and analyzed in different categories based on the previous literature review.

The rest of the thesis is organized in following structure. The "Literature Review and Theoretical Background" chapter reviews the literature of precious work, introduces the related theoretical concepts, and indicates the research gap. The "Methodology" chapter indicates the methodology of this thesis, introduce how the interviews are structured and conducted. The "Data" chapter will do descriptive analysis of the trade flows for semiconductor supply chain in Estonia, reveal the changes see if they are in line with the previous literature review. The "Result and Analysis" chapter will analysis the results from interviews. The "Conclusion and Managerial Implication" chapter will draw conclusion from this research and suggest implications for existing problems. The last chapter "Limitation" indicates the limitations of this study.

2. Literature Review and Theoretical Background

2.1 Semiconductor Supply Chain

In general, the semiconductor supply chain is a collection of companies that design and manufacture semiconductors and semiconductor devices, such as transistors and integrated circuits. The semiconductor industry was founded around 1960 when the manufacture of semiconductor devices became a viable business. At the same time, the semiconductor industry is also the driving force behind the broader electronics industry (Semiconductor Industry Association, 2018). Major countries like the US are investing heavily in semiconductor industry (Asan Institute for Policy Studies, 2021).

The semiconductor one of the most globalized industries in the world semiconductor supply (Grimes & Du, 2022). There are different stages in its value chain

(Liu, n.d.). Figure 1 illustrates the semiconductor production begins with R&D and ends with distribution.

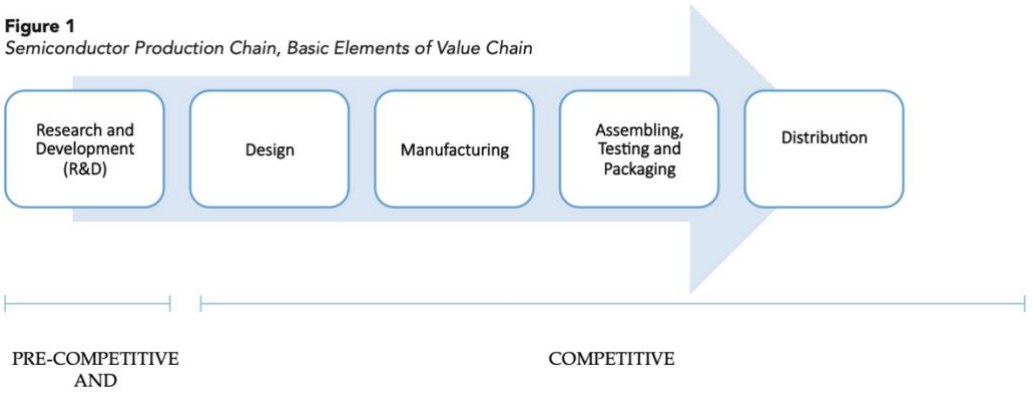

Figure 1. Semiconductor Production Chain

Source: Semiconductor Industry Association, May 2016

In the semiconductor value chain, the distribution stage is the most critical stage regarding supply chain (Godding et al., 2003). In this regard, only the distribution stage will be focused on in this thesis.

While the current tensions between the US and China may be seen as a unilateral attempt by the US to block China's attempts to achieve greater autonomy in the semiconductor sector, China has been moving toward the goal of autonomy for some years, particularly since Snowden's cybersecurity revelations, when the push for indigenous technology development began to kick in, and more recently with the highly ambitious goals for autonomy set out in the Made in China 2025 Plan (Grimes & Du, 2022). As for Estonia, China is its largest source of semiconductor imports in the year 2021 (*Statistic Estonia Database*).

Hunt (2022) indicates that since 1990, the U.S. share of global semiconductor manufacturing capacity has declined while the shares of South Korea, Taiwan, and China have increased. BCG’s study further predicts that the further manufacturing locations shall incline more to Asia.

Figure 2 illustrates the changes in semiconductors' global manufacturing capacity by location (%) below:

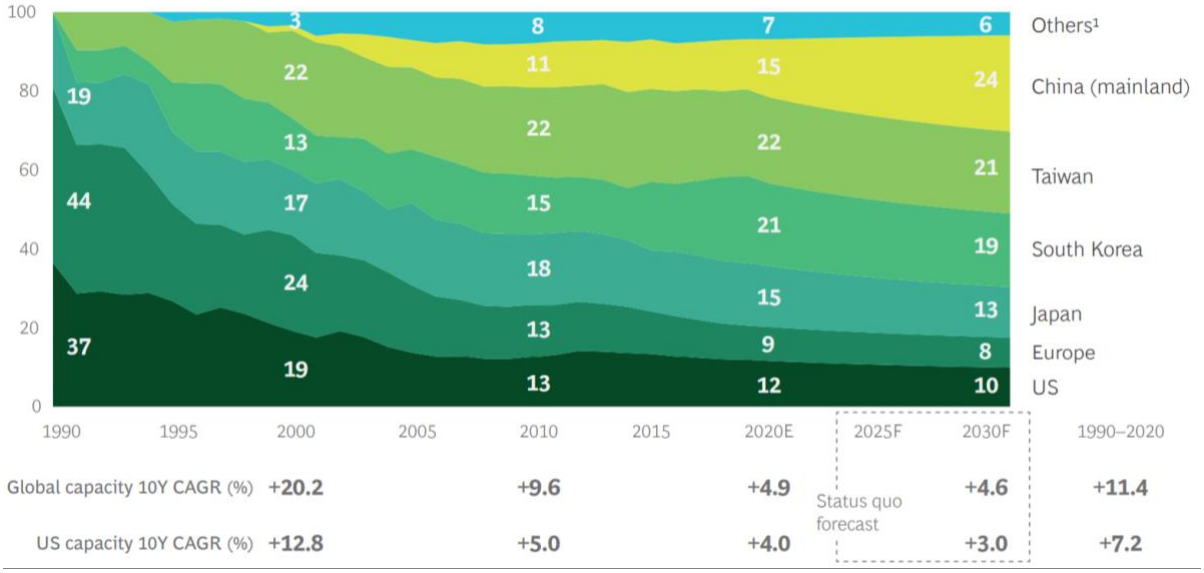

Figure 2. Global Semiconductor Manufacturing Capacity by Location (%)

Source: VLSI Research projection, SEMI second-quarter 2020 update; BCG analysis

2.2 Electronic Manufacturing Industry in Estonia

Estonia is chosen as to be studied in this thesis for being one of the most open economy in the world (Kiisler et al., 2020). It is very much dependent on foreign trade. As of the year of 2021, 81% both in imports and export from GDP (*International Trade - Trade in Goods and Services - OECD Data*, n.d.).

Prior studies about electronic manufacturing industry in small developed countries like Estonia by Ein-Dor et al., (1997) and Lemola & Lovio (1988). They took countries like New Zealand, Israel Singapore, and Finland as examples, described electronic manufacturing industry in small, developed countries as exporting oriented as these

countries have small domestic market. However, these studies are from last century. The world trade has changed significantly in recently years.

As of 2019, 93% of the Estonian electronics industry's output is for export, which makes 23% of all Estonia's exports (*Smart Electronics from Estonia*). As of the year of 2018, there are over 230 electronics manufacturing companies and 12 000 employees, the electronics industry is one of the largest industrial sectors in Estonia with significant contribution to the GDP (*Electronics Industry in Estonia*, 2018). Manufacturing of electronic and electrical equipment has been one of the fastest growing industries in Estonia (*Smart Electronics from Estonia*, 2019). There are several major electronic manufacturing companies in Estonia, namely ABB, Ericsson, Eolane, Stoneridge, Enics and Incap. As of the year 2021, the total value of semiconductor importing in Estonia is 71,811,298 Euros.

2.3 OBM Company and EMS Company

There are many different types of manufacturing companies in the electronics industry. The main ones are Electronics Manufacturing Service (EMS), Original Brand Manufacturer (OBM).

EMS plays a role as a contract manufacturer in the electronics industry. EMS can design, manufacture, test, ship, or repair electronic components and assemblies for OEMs (original equipment manufacturers). They may also be involved in product development, software design assistance, or other value-added services such as supply chain management, make-to-order configuration, and outbound logistics (Barnes et al., 2000). Some EMS companies are large multinational corporations that manufacture components for companies such as Huawei, Apple, and Lenovo.

OBM is responsible for the entire production process from design, engineering, manufacturing, and supply chain to marketing. An OBM owns the brand and product. OBM is the choice for manufacturers who want to produce complex products. Compared to EMS, the cost (both money and time) to produce a product is usually higher for OBM

(Wing Fung Yeung, 2020). One good example is Motorola, which designs and manufactures its own products and runs its own supply chain to the market and sells them.

Different types could mean the different services that are involved in this regard. OBM covers the whole value chain of the electronic manufacturing industry. EMS only covers part of the electronics manufacturing industry. Many of the electronic manufacturing companies adopts the “Reverse Value Chain" Strategy (from EMS to OBM) (Poh-Kam Wong, 1999). The EMS and OBM stand for two typical company types. The main difference in terms of value-adding between EMS and OBM can be explained by the concept of “the Smile Curve”. So, only these two major types, OBM and EMS, will be discussed in this thesis. Figure 3 illustrates the basic difference between OBM and EMS.

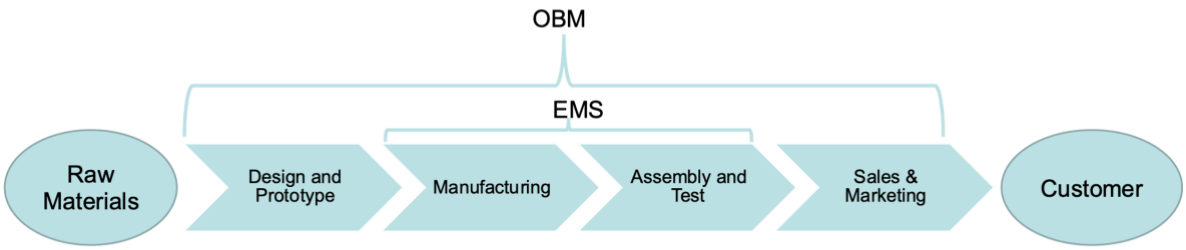

Figure 3. Supply Chain of Electronic Manufacturing industry
Source: Made by the author

The concept of the smile curve was first proposed by Stan Shih (1992), the founder of Acer, a technology company headquartered in Taiwan. Shih (1996) highlighted that in the personal computer industry, both ends of the value chain command higher value added to the product in comparison to the middle part of the value chain. In this regard, although some parts will still be outsourced, like monitor panels, the OBM industry covers almost

the whole range of the smile curve. On the other hand, for the EMS industry, as it is merely involved in the manufacturing stage, its value-adding is significantly lower than that of the OBM industry. For a manufacturing company, its final goal is to become an OBM (Yang et al., 2010). Mudambi (2008) made an illustrative graph of the smile curve, as shown in Figure 4.

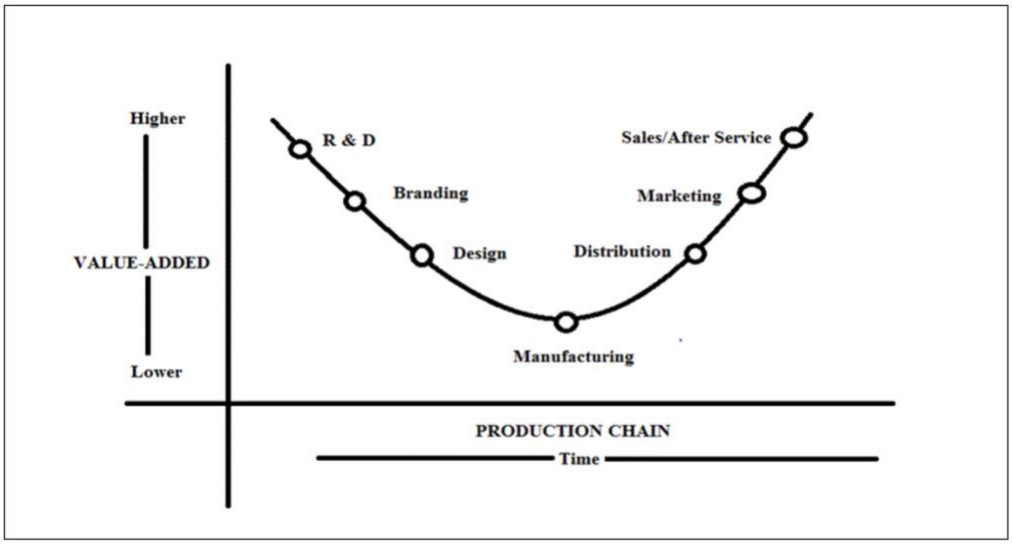

Figure 4. The Smile Curve and Global Value Chain (GVC).

Source: Mudambi (2008)

As it's shown in Figure 4, EMS covers the merely the manufacturing stage of the Smile Curve, while OBM cover all stages of the Smile Curve. This indicts that the OBM is more value-adding than EMS.

2.4 Supply Chain Resilience of Semiconductor Supply Chain

The concept of supply chain resilience has been actively researched and studied since early 2000s (Pettit et al., 2019). Christopher & Peck (2004) brought up the concept of supply chain resilience that draws the attention in the manufacturing industry. There are different ways in which the supply chain is influenced. The Covid-19 Pandemic has been the most challenging shipping environment for supply chain and logistics professionals in our observed history (Jaap Bruining, Head of Europe, Coyote Logistics on July 31, 2020).

Logistics has a significant impact on supply chain as well. Kong (2016) defines resilience as “the capability of an organization to recuperate from supply chain disturbances or to adjust quickly according to the adversities or disorders”.

Especially in the past three years, the studies mainly focused on the trade friction and the COVID-19 pandemic (Handfield et al., 2020). The literature review of this part will focus on the supply chain in general and the semiconductor industry.

Geopolitical issues bring instabilities as well. Grimes & Du, (2022) indicated that the growing tensions between the US and China has created considerable uncertainty about the future of semiconductor supply chain. Chen & Leong's (2022) study also revealed the fragility of semiconductor supply chain due to the trade tensions. Apart from that, Techno-Nationalism is also one of the possible reasons for the trade war (Luo, 2022). Techno-nationalism and techno-globalism are descriptive and prescriptive categories for understanding the impact of technology on society (David E. H. 2007), which eventually led to the impact on global trading and Trade Protectionism. For example, (Peters, 2019) stated that the fear that China's technology will drive Washington has been impacting the West because of Chinese techno-nationalism. This phenomenon is particularly obvious in the high technology industry like the semiconductor industry. With these worries, many companies are embracing “China Plus One” strategy (Zhang & Huang, 2012), to alleviate geopolitical risk on supply chain (M & V, 2022).

2.5 Trade-offs Between Risk and Cost in Supply Chain Management

Chopra & Sodhi（2014) stated that there two kinds of risks in supply chain, which are recurrent risks such as demand fluctuations that mangers must deal with in supply chain and disruptive risk that require companies to build resilience despite additional cost. In attempting to differentiate supply chain risks, many scholars have proposed typologies and/or taxonomies or risks (Maslarić et al., 2013). Figure 5 illustrates the trade-off between risk and cost in the supply chain as below:

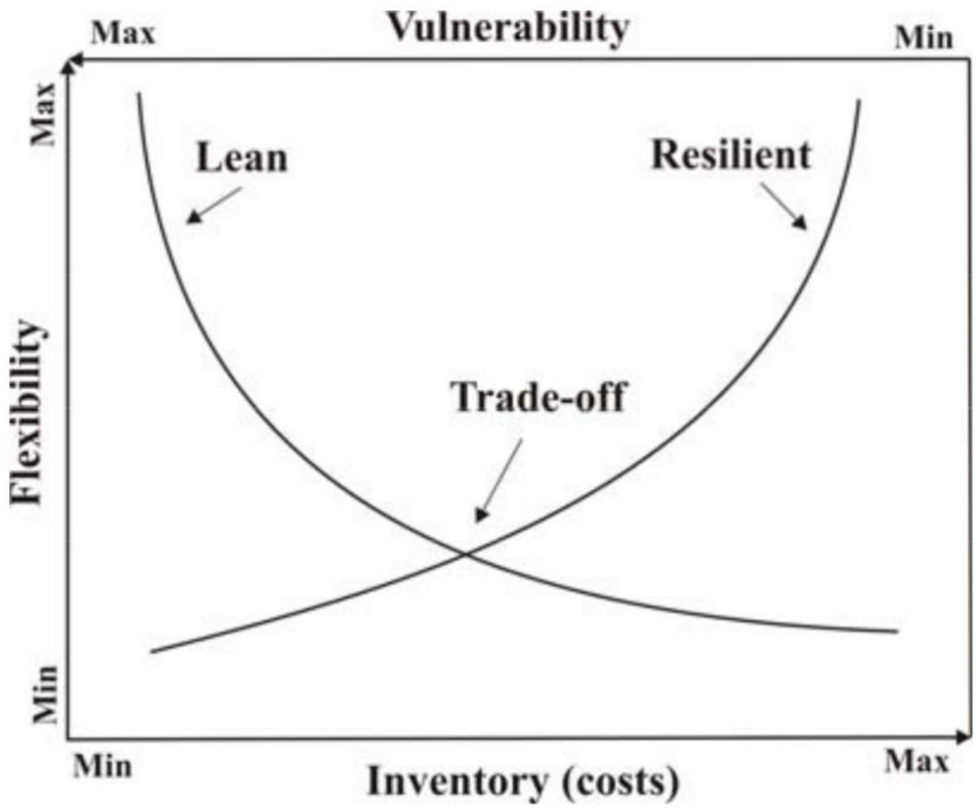

Figure 5. Trade-Off Between Risk and Cost in the Supply Chain

Source: Maslarić et al., (2013)

Machado & Duarte (2010) stated that when risk events occur, supply chains tend to break down and take a longer time to recover. This ability of the companies to resist a serious damaging event and to return to the previous state is called resilience.

Sheffi, Y (2005) describes three main approaches companies can develop resilience: adding redundancy, improving flexibility, and switching to new corporate culture. Although other concepts are discussed in academic articles, most of the topics discussed usually fall into one of these three strategies, as mentioned above. The easiest way to improve the supply chain resilience is to increase redundancy throughout the whole supply chain, which means keeping some additional resources which in this case means the

inventory in reserve to be used when there is a disruption in the supply chain. However, this contrasts with the concept of lean thinking that advocates waste reduction and zero inventory operations. Thus, as a balance between resilience and cost emerged, this trade-off is a rather important concept in supply chain management.

2.6 Overview of the Previous Studies about Semiconductor Supply Chain in Estonia

To sum it up, recent study by Kiisler et al., (2020) shows the main issue of supply chain in Estonia are purchasing and demand prediction. Makarychev & Wishnick (2022) also stated that the important role of geological confrontation is playing in Estonia's supply chain. In Europe, the share of global trade declined from 22% in 1988 to 13% in 2010 (CARSA et al., 2020), and continuing to 8.7% in 2021(Ravi, 2021). This made EU countries like Estonia depend more on importing regions outside of EU.

However, as an important part of Estonia's electronic manufacturing industry, semiconductor supply chain has not yet been focused on yet. The overview of previous studies is categorized into three main groups, which serves the empirical part of the thesis. Table 1 indicates the Overview of the Previous Studies about Semiconductor Supply Chain in Estonia, the factors are selected based on David's (2011) "Strategic Management Concepts".

Table 1.

Overview of the Previous Studies about Semiconductor Supply Chain in Estonia

	Factors	Literatures
Internal	Integrating Strategy	Barnes et al., 2000
	Internal R&D	Wing Fung Yeung, 2020
	Production/d\Value-Adding of the Covering Stages	Stan Shih, 1992
		Yang et al., 2010

		Mudambi. 2008
External	Political Force	Hunt, 2022
		Grimes & Du, 2022
		Zhang & Huang, 2012
		Luo, 2022
	Economical Force	Kiisler et al., 2020
		Lemola & Lovio 1988
	Technological Force	Poh-Kam Wong, 1999

Source: Made by the author.

One of the bases from the selected literatures is whether the factors have an impact on semiconductor supply chain in Estonia. The overall changes of semiconductor manufacturing capacity from the US and Europe to Asia could have an impact on the reconfiguration of a small and developed EU country like Estonia, however, the correlation is not clear. Different types of companies could have different supply chain strategy, which led to different approaches of supply chain reconfiguration. However, how different types of electronic manufacturing companies would reconfigure their semiconductor supply chain has not been indicated in the previous literature.

3. Methodology

In order to achieve the goal of this thesis, spreadsheet tools are used to visualize the data. 4 semi-structured interviews with the professional managers in the industry from different types of electronics manufacturers are conducted by the author from March 2022 to April 2022.

The semi-structured interviews are widely used in supply chain analysis. Blackhurst et al., (2005) used semi-structured interviews to study the automotive supply chain. Fawcett et

al., (2006) used semi-structed interviews to gather data to identify the types and extent of managerial support. Cao et al., (2017) conducted semi-structured interviews of four different companies in the United States to analysis the use of cloud computing in supply chain management. Compared with other types of interviews, the semi-structured interviews allow an open response in the participants' own words rather than a "yes or no" type answer (Clifford et al., 2016). The general structure of those questions is categorized into different groups. At the same time, some questions are open-ended, so the interviewees can add different inputs to the answers. Table 2 shows the general protocol of this interview:

Table 2.

Interview protocol.

Interview type	Semi-structured interview
Type of interviewees	Senior level manger, SCM manager
Number of respondents	4
Interview method	MS Teams, on-site
Language	English
Question type	Open-ended

Source: Made by the author.

These semi-structured interview questions are listed in Appendix B.

Interactive interviews are conducted in the empirical part. When it comes to the interview questions, several general approaches are followed to format interview questions based on the overview of the previous studies about semiconductor supply chain in Estonia (Table 1). This interview is conducted in an interactive manner, so it's more of a question

list rather than a questionnaire. More specifically, Table 3 shows the interview question category as below:

Table 3.

Question category

Questions	
General questions	Considering the trade-offs between risk and cost in the supply chain (as shown in the chart below), how would you describe your company's supply chain strategy?
	What is your position in the company?
	What percentage of the company's total supply chain costs do semiconductor components account for?
Internal	What is the current action that your company is taking regarding countries of origin?
	What best describes the upcoming strategy regarding the countries of origin?
	What is (are) the reason (s) your company is switching to other LLCs (Low-Cost Countries)?
External	What is (are) the reason (s) your company is switching from China to other LLCs (Low-Cost Countries)?
	Are there any other company-level reasons you would like to add that led to the changes?

4. Data

In the thesis, the descriptive analysis of changes of semiconductor supply in Estonia in the past four years (from 2018 to 2021) is conducted based on the open data from the database Statistic Estonia. The HS code CN8541 (Semiconductor devices," e.g., diodes, transistors, semiconductor-based transducers"; photosensitive semiconductor devices, incl. Photovoltaic cells, whether assembled in modules or made up into panels (excl. photovoltaic generators); light emitting…) is used as the analyzing object. I will be using different visualization tools like Excel to illustrate the changes in trade flow.

Firstly, the trade data for the past four years (2018-2021) was exported from Statistics Estonia. Since there are too many countries to focus on, the trade value in the past four years is summed up and sorted up in descending order, and the top 20 importing partners are selected, as shown below:

Table 4.

Top 20 exports and imports of goods by Flow, Commodity (by HS CN8541), Country, Indicator and Reference period, commodity value, rounded in thousand euros

Imports by country of origin	**2018**	**2019**	**2020**	**2021**	**2022**
CN China	13071	14693	60673	21701	1609
MY Malaysia	4978	5635	2877	13777	177
DE Germany	7812	4524	8830	5248	349
SE Sweden	10130	9908	949	3415	183
NL Netherlands	19287	1192	1456	815	9
JP Japan	2206	1602	2471	2460	234
FI Finland	3411	1931	1745	1288	60
PL Poland	1781	1129	2750	2386	278
TW Taiwan (CN)	3053	1256	2231	1165	63
TH Thailand	2570	1620	1820	1440	118
US United States	3024	2031	1598	812	33
PH Philippines	1811	995	780	1384	225
LT Lithuania	360	1154	1335	2109	78
VN Vietnam	3382	871	518	36	3
RU Russia	964	1489	1314	882	108

KR South Korea	471	1014	981	1260	105
UK United Kingdom	1031	741	540	277	10
BE Belgium	627	639	531	522	49
IN India	828	647	232	327	4
SK Slovakia	137	514	597	664	54

Source: Statistics Estonia

A visualization of Where does Estonia imports Semiconductor devices (January 2018-January 2022) from Statistics Estonia is shown below in Figure 6:

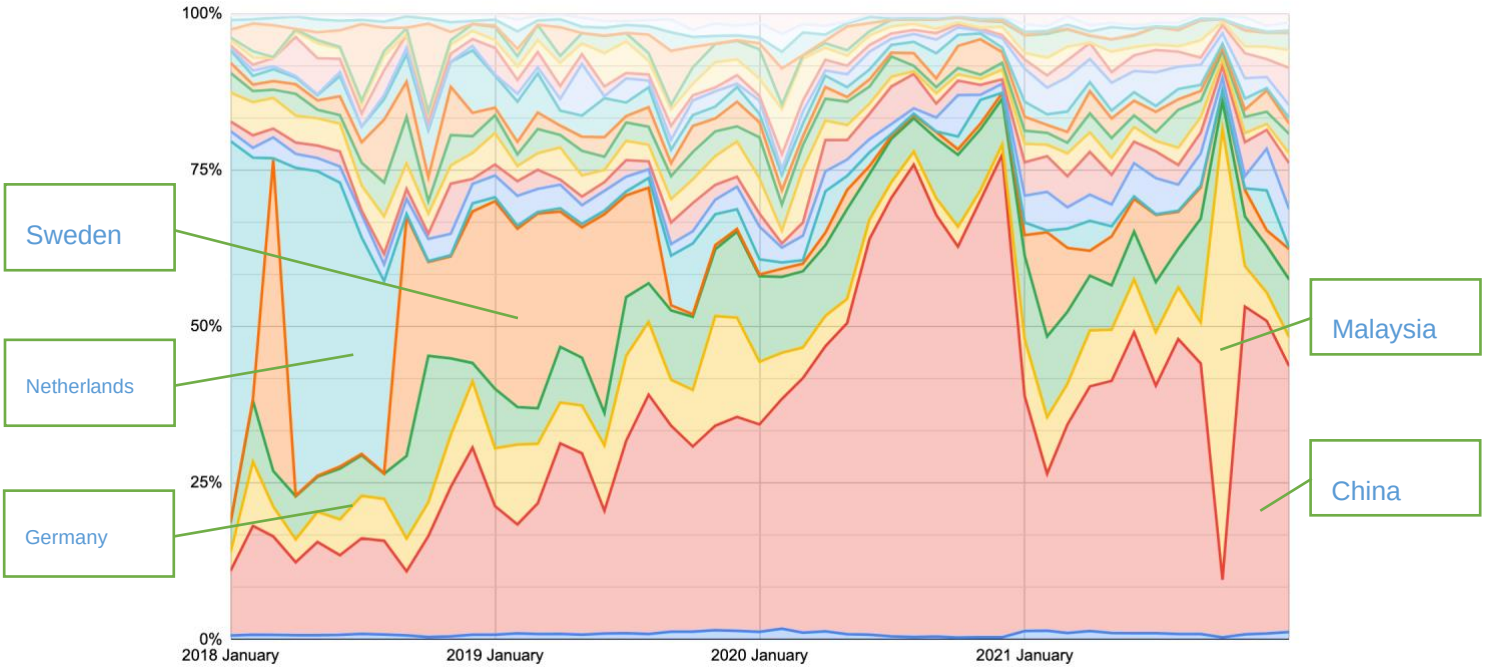

Figure 6. Countries of Origin of Semiconductor imported to Estonia from Jan. 2018 to Jan. 2022

Source: Constructed by the author

Figure 6 shows that China has been playing a significant role in importing semiconductor components in the past four years. However, countries like Malaysia are taking over China's dominance of semiconductor components supply. Overall, the data

shows that around 98.1%[1] of total imports in the past four years are from Europe and Asia, so it is reasonable to focus on those two continents. If the data is observed on a continental level, the trend can be found from another angle.

Figure 7 which is in a format of a 2-D 100% stacked area to show the share in each year's countries of origin, is shown as follows:

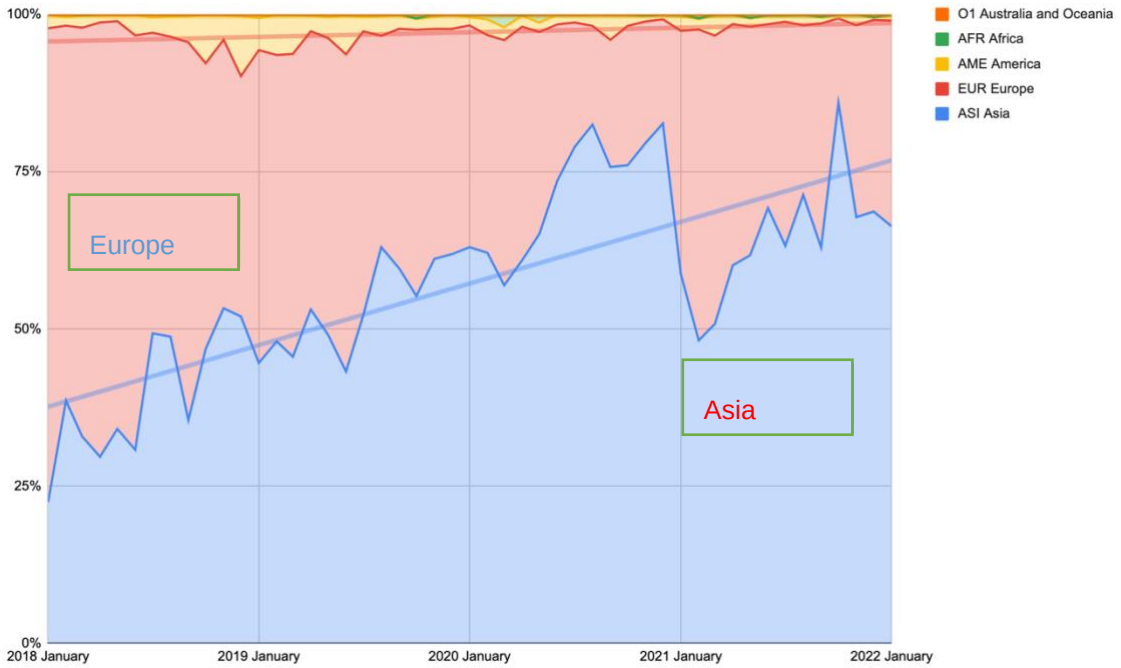

Figure 7. Continents of Origin of Semiconductor imported to Estonia from Jan. 2018 to Jan. 2022

Source: Construct by the author based on data from Statistics Estonia

[1] Calculated from the total imports value from Jan. 2018 to Jan. 2022

Figure 7 shows that Asia as a continent plays a more important role in this regard. The data that is used in this article can be found in the Appendix A. The top 10 importing partners are chosen and visualized as below in Figure 8:

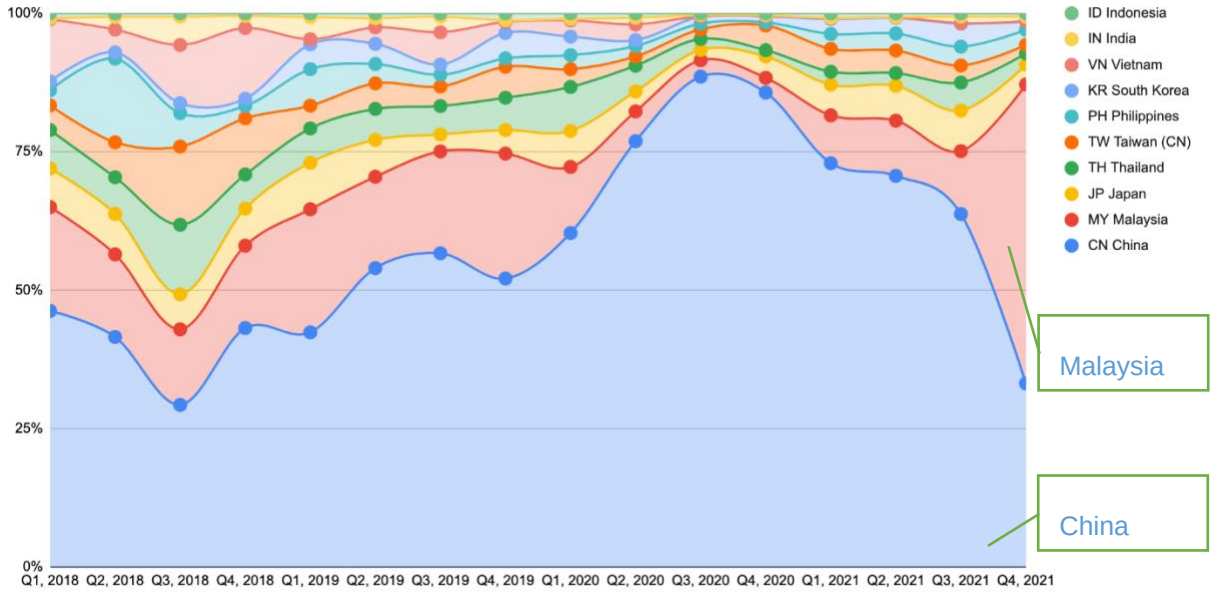

Figure 8. Top 10 Countries of Origin of Semiconductor imported to Estonia by quarter from Q1 2018 to Q4 2021

Source: Made by the author based on data from Statistics Estonia

Figure 8 shows that within Asia, apart from China, Malaysia plays a more important role in this regard. Figure 8 also suggests that the importing destination is switching from Europe to Asia, which are China and Malaysia. The importing value leans from China to Southeast Asia, for example, Malaysia.

Significant changes have happened since the COVID-19 outbreak. The data from Jan. 2020 to Jan. 2022 suggests that as much as China still plays an important role in the market, countries like Malaysia catch up to take more share of the importing destination. In this case, the growth rate on a monthly year-on-year basis is investigated. Figure 9 illustrates the changes:

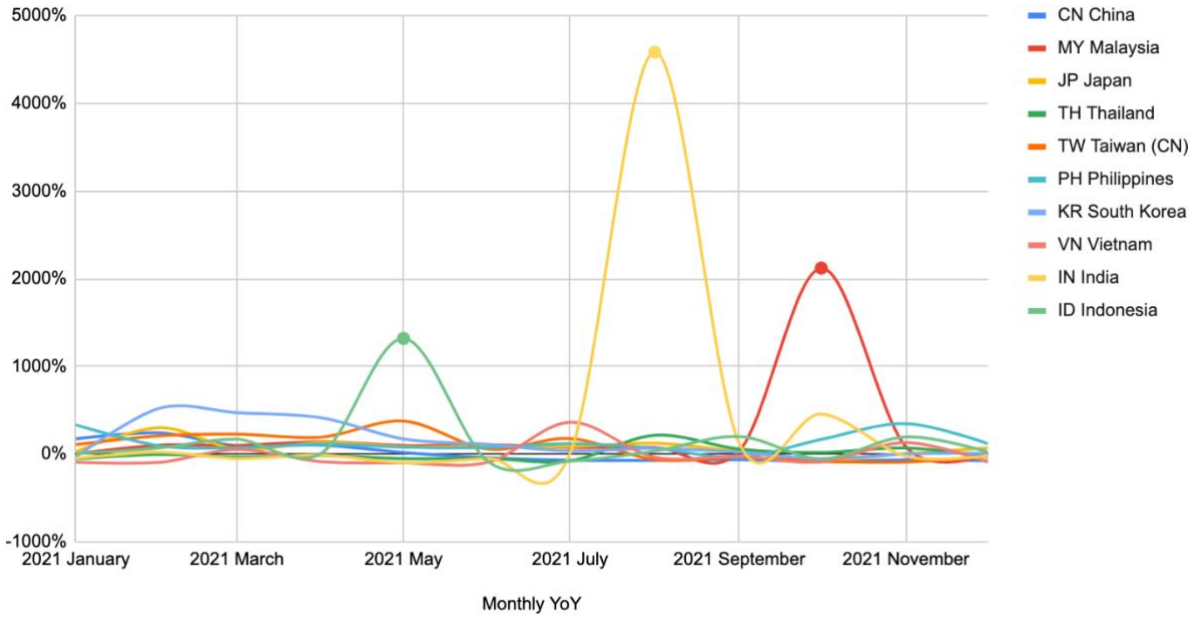

Figure 9. Top 10 Countries of Origin of Semiconductor imported to Estonia monthly year on year growth in 2021

Source: Made by the author based on data from Statistics Estonia

There are several abnormal numbers that are beyond 1000%, namely India, Indonesia, and Malaysia, which are mainly due to sporadic purchases. To round numbers up, the quarterly year on year growth is made as follows:

Table 5.

Top 10 Countries of Origin of Semiconductor imported to Estonia Quarterly year on year growth in 2021

Imports by country of origin	**Q1, 2021**	**Q2, 2021**	**Q3, 2021**	**Q4, 2021**
CN China	155%	6%	-70%	-76%
MY Malaysia	53%	113%	62%	1143%
DE Germany	80%	101%	66%	-43%
SE Sweden	-38%	-43%	8%	11%
NL Netherlands	170%	182%	-25%	-79%
JP Japan	124%	88%	40%	199%

FI Finland	71%	203%	36%	-15%
PL Poland	-91%	-97%	-9%	-83%
TW Taiwan (CN)	-38%	-94%	121%	377%
TH Thailand	76%	-1%	-21%	9%

Source: Statistics Estonia

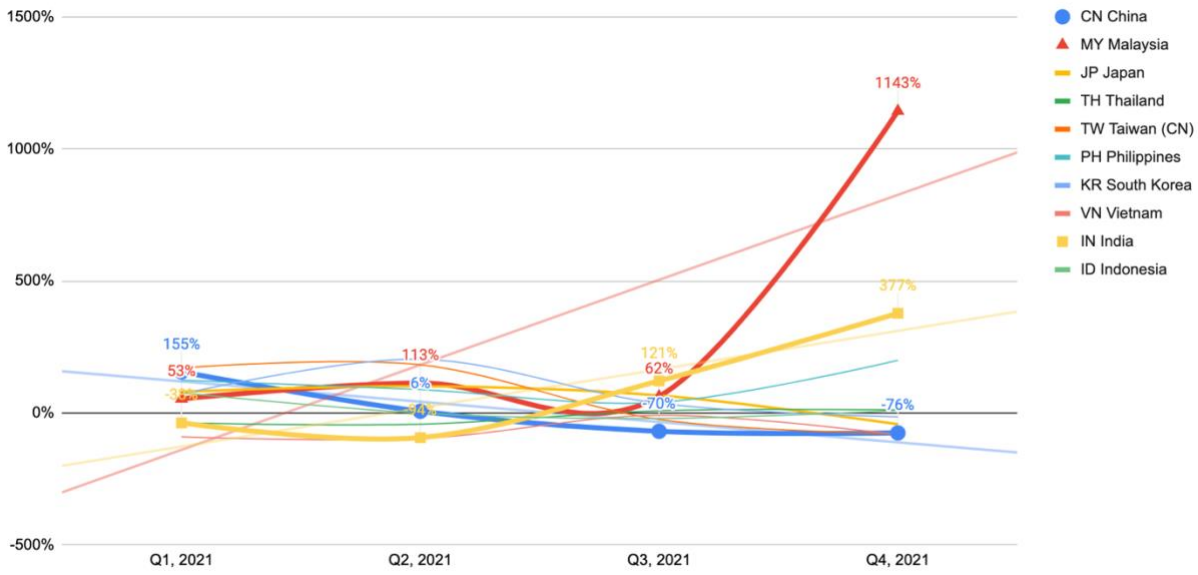

Figure 10. Top 10 Countries of Origin of Semiconductor imported to Estonia Quarterly year on year growth in 2021

Source: Made by the author based on data from Statistics Estonia

Figure 10 shows that within Asia, although China still dominates the semiconductor supply to Estonia, the other Asian countries, especially those that are LCC (low-cost countries), are catching up. So, the research proposition that there is a reconfiguration of semiconductor supply chain in Estonia, which is "from Europe to Asia, from Northeast Asian countries and regions like China, Japan, Taiwan (CN) and South Korea to LLCs in Southeast Asian countries like Malaysia and Philippines" is in line with the data.

Overall, Figure 8 reveals that the gradual changes of semiconductor supply chain from Europe to Asia. This is in line with the overall changes of global semiconductor manufacturing capacity by location overtime (Figure 2). The semiconductor manufacturing capacity shapes the basic structure of the supply chain in Estonia. At the same time, because of the worries of trade tensions between the US and China, companies are actively in search of more possible supply channels (like China Plus One) while depending on one single source. Figure 9 and Figure 10 show this trend that while supply chain remains growing in Asia, it turns to other low-cost countries apart from China.

5. Results and Analysis

5.1 Main Findings from the Interviews

The first two interviewee are from an EMS company. This company is a medium size industry electronic manufacturing company. Majority of its products are exported to other EU countries.

Main findings from the first two interviews from an EMS company are as follows n this company, 45% of the total value of the company's raw material cost goes to semiconductor-based components. Considering the nature of the EMS industry, which has a low-profit margin, this company and most of the companies in the industry are risk-seeking companies. They would rather have a stable business relationship with one single source supply to cut the cost for greater revenue. Regarding the supply chain strategy before, the interviewee mentioned that similar to the cost-risk-resilience model, EMS providers are usually risk-seekers. They highly depend on one single source. For question 6, option B best describes the supply chain strategy. This is to consider the China Plus One strategy while remaining in Asia's current supply chain strategy. When it comes to why the company is doing so, this interviewee mentioned the growing labor cost, high logistics cost, and strict covid policy that causes instability in the supply chain. Another reason, as the interviewee stated, was the low-profit margin nature of the EMS industry. The company is slowly leaning toward a "buy locally, sell locally" strategy, mainly because of marginal

utility in LLCs and the European Single Market in its European performance centers and the high tariffs and logistics cost due to the high percentage of raw material expenditure from its total cost. A significant reason why this company is buying from Asia, especially China, is the great development of semiconductor manufacturing capacity in recent years.

The third and fourth interviewee are from an OBM company. This company is a medium size telecommunication manufacturing company. Majority of its products are exported to other EU and Asian countries.

Main findings from the third interview from an OBM company are as follows: Around 5% of the total value of this company's raw material is semiconductors. Considering the nature of an OBM company, which usually has a high-profit margin, these companies would trade higher costs and inventory with higher resilience. An OBM company tends to be risk aversion when it comes to the cost-resilience trade-offs. When this article was written, the global market was facing a situation that there was currently a war happening between Russia and Ukraine, which led to high energy prices. In this case, a higher inventory would favor the overall turnover. The current low bank interest in Europe. The interviewees' words, "you will get punished for putting your money in the bank." With the rapidly growing raw materials market price, maintaining a high inventory favors a high turnover. Instability in global trading is still going on in the foreseeable future. A high inventory is in favor of a stable supply chain.

Main findings from the fourth interviewee from an OBM company are as follows: Around 5% to 10% of the total value of this company's raw material is semiconductors. This company is a risk aversion one. However, there are not a lot of choices to make in the market. In this sense, high cost does not necessarily lead to high resilience. When it comes to supply chain management in terms of where to procure the semiconductor-based components, the strategy has always been that it considers China plus one strategy in Asia while maintaining the current supply chain in China. As a company that focuses on high

value-added and logistics, the limited supply capacity of China's semiconductor industry is the reason why the company is switching its suppling chain from China to other LLCs.

5.2 Analysis of the Main findings

The results from the two types of companies are quite different.

Table 6 is made to compare the difference between answers from the OBM company and the EMS company:

Table 6. Comparison between answers from an OBM company and an EMS company

Questions	OBM	EMS
Considering the trade-offs between risk and cost in the supply chain (as shown in the chart below), how would you describe your company's supply chain strategy?	risk aversion	risk seeking
What percentage of the company's total supply chain costs do semiconductor components account for?	5%-10%	45%
What is the current action that your company is taking regarding countries of origin?	One single source	China Plus One Strategy
What best describes the upcoming strategy regarding the countries of origin?	One single source	China Plus One Strategy
What is (are) the reason (s) your company is switching to other LLCs (Low-Cost Countries)?	One single source	China Plus One Strategy
What is (are) the reason (s) your company is switching from China to other LLCs (Low-Cost Countries)?	The strict covid policy that causes instability in the supply chain	Limited supply capacity of China's semiconductor industry

Source: Made by the author.

The interviewees from an EMS company as well as their company are risk-seeking ones. With a high percentage of semiconductor purchasing value, in which semiconductor consists 45% of the total purchase value, the company chooses to have a relatively consistent business relationship with a single source, usually from one country. As part of the nature of the EMS industry, it mainly focuses on the manufacturing and testing part of the industry. On the one hand, the most value-adding part like R&D or sales belongs to its customers. On the other hand, the EMS provider does not have a complete control of the suppliers because some parts, especially the core parts, which are customer-controlled materials.

Regarding the changes in where the company sources its materials, the interviewees from the first company (EMS) emphasized that the main reason is that the semiconductor suppliers are slowly switching to Asia. Due to reasons like lower labor costs being close to the upstream suppliers, Asia can supply with lower prices.

The interviewees from an OBM company, as well as their company, are risk aversion ones. Semiconductors only consist of 5% of the total purchase value in this company. This company chooses to put its cash flow in the material inventory as a strategic action. Regarding the countries of origin, it's not as sensitive as the EMS company. As the long lead time in the semiconductor market is high, it's actively seeking for any source that can fulfill the demand.

Several challenges a business in the industry faces can be drawn from the results:

The current supply chain structure does not fulfill the need for electronic manufacturing companies in Estonia. Supply chain shall be reconfigured. As Ravi, (2021) indicated, the overall semiconductor capacity is switch from Europe to Asia, which forced companies in Estonia to adapt to this change. The authors analysis on the trade flow also supports this proposition.

OBM companies choose resilience over cost by choice stable supply. EMS companies have to choose cost over resilience due to low profit. As Yang et al., (2010) stated, EMS companies final goal is to become OBM ones.

Geopolitical issues intensify the semiconductor supply chain instability. This is in line with studies by Hunt (2022), Grimes & Du (2022), Zhang & Huang (2012), Luo (2022). China Plus One Strategy is more welcome for companies with low profit like EMS companies.

6. Conclusion and Managerial Implication

In summary, this thesis reveals the reconfiguration of semiconductor supply chain in Estonia and the reasons to the reconfiguration. Based on the challenge to a business in the industry, the study provides several managerial implications.

Firstly, this study indicates that there is a reconfiguration of semiconductor supply chain in Estonia. Some of the reasons are the low cost of semiconductor supply in low-cost countries, strict covid policy that causes instability in the supply chain, and the limited capacity of semiconductor supplying from one single country source. The overall changes in Estonia's semiconductor supply chain are that it is “from Europe to Asia, from Northeast Asian countries and regions like China, Japan, Taiwan (CN) and South Korea to LLCs (Low-Cost Countries) in Southeast Asia like Malaysia and Philippines ".

Secondly, for a company with relatively high marginal profit, like an OBM company, which is at or covering the high value-adding stage of the "smile curve," it is risk aversion. For these kinds of companies, it’s less likely to reconfigure their semiconductor supply chain due the bad trade-off between resilience and cost. Vice versa, for a company with relatively low marginal profit, like an EMS company, which is at the relatively low value-adding stage of the "smile curve," it is risk-seeking. A risk-seeking company is more likely to reconfigure its semiconductor supply chain compared with a risk aversion one.

Thirdly, geopolitical issues play a very important role in semiconductor supply chain. They intensify the semiconductor supply chain instability. To alleviate this issue, strategies like "China Plus One" strategy could be taken by Estonian companies. Companies shall source semiconductor-based components from China should be considered as part of the future sourcing strategy. At the same time, considering the risk factors in the China market, having a backup plan in other low-cost countries helps maintain a rather strong supply chain resilience.

7. Limitation

This study is mainly based on the open data from the years 2018 to 2022 for the purpose of focusing on the most recent changes in the global semiconductor supply chain. However, this comes with disadvantages. Many of the phenomena evolved in rather earlier times, to be observed as they are nowadays. The analysis of the past four years cannot reveal all the changes in Estonia's supply chain reconfiguration.

The samples of the interviews are rather a few. In total, four interviews from two companies were conducted. Some of the insights could be biased due to the positions where the interviewee serves in the company.

8. Reference

1. Barnes, E., Dai, J., Deng, S., Down, D., Goh, M., Lau, H. C., & Sharafali, M. (2000). Electronics Manufacturing Service Industry. *Research Report, Logistics Institute, School of Industrial Engineering, Georgia Tech*.
2. Blackhurst *, J., Craighead, C. W., Elkins, D., & Handfield, R. B. (2005). An empirically derived agenda of critical research issues for managing supply-chain disruptions. *International Journal of Production Research*, *43*(19), 4067–4081. https://doi.org/10.1080/00207540500151549
3. Bown, C. P. (2020). *How the United States Marched the Semiconductor Industry into its Trade War with China* (SSRN Scholarly Paper No. 3766574). Social Science Research Network. https://doi.org/10.2139/ssrn.3766574
4. Cao, Q., Schniederjans, D. G., & Schniederjans, M. (2017). Establishing the use of cloud computing in supply chain management. *Operations Management Research*, *10*(1), 47–63. https://doi.org/10.1007/s12063-017-0123-6
5. CARSA, Decision SARL, Directorate-General for Communications Networks, C. and T. (European C., Coulon, O., Olliver, J. K., Dubois, G., Saint-Martin, L., & Vodovar, M. (2020). *Study on the electronics ecosystem: Overview, developments and Europe's position in the world : annex 3*. Publications Office of the European Union. https://data.europa.eu/doi/10.2759/5658
6. Chen, M.-J., & Leong, J. (2022). *Geopolitics and the Global Semiconductor Industry* (SSRN Scholarly Paper No. 4085009). Social Science Research Network. https://doi.org/10.2139/ssrn.4085009
7. Chopra, S., & Sodhi, M. S. (n.d.). *Reducing the Risk of Supply Chain Disruptions*. 15.
8. Christopher, M., & Peck, H. (2004). *Building the resilient supply chain.* https://doi.org/10.1108/09574090410700275
9. Clifford, N., Cope, M., Gillespie, T., & French, S. (2016). *Key Methods in Geography*. SAGE.
10. David, F. (2011). *Strategic Management Concepts and cases*. Pearson Education Limited. http://localhost:8080/xmlui/handle/123456789/797
11. dcadmin. (2018, February 5). *Annual Semiconductor Sales Increase 21.6 Percent, Top $400 Billion for First Time*. Semiconductor Industry Association. https://www.semiconductors.org/annual-semiconductor-sales-increase-21-6-percent-top-400-billion-for-first-time/
12. Ein-Dor, P., Myers, M. D., & Raman, K. S. (1997). Information Technology in Three Small Developed Countries. *Journal of Management Information Systems*, *13*(4), 61–89. https://doi.org/10.1080/07421222.1997.11518143
13. *Electronics industry in Estonia—Eesti Elektroonikatööstuse Liit*. (n.d.). Retrieved May 11, 2022, from https://www.estonianelectronics.eu/electronics-industry-in-estonia
14. Fawcett, S. E., Ogden, J. A., Magnan, G. M., & Bixby Cooper, M. (2006). Organizational commitment and governance for supply chain success. *International Journal of Physical Distribution & Logistics Management*, *36*(1), 22–35. https://doi.org/10.1108/09600030610642913

15. Godding, G. W., Sarjoughian, H. S., & Kempf, K. G. (2003). Semiconductor supply network simulation. *Proceedings of the 2003 International Conference on Machine Learning and Cybernetics (IEEE Cat. No.03EX693)*, 1593–1601. https://doi.org/10.1109/WSC.2003.1261607
16. Grimes, S., & Du, D. (2022). China's emerging role in the global semiconductor value chain. *Telecommunications Policy*, *46*(2), 101959. https://doi.org/10.1016/j.telpol.2020.101959
17. Handfield, R. B., Graham, G., & Burns, L. (2020). Corona virus, tariffs, trade wars and supply chain evolutionary design. *International Journal of Operations & Production Management*, *40*(10), 1649–1660. https://doi.org/10.1108/IJOPM-03-2020-0171
18. Hunt, W. (2022). *Sustaining U.S. Competitiveness in Semiconductor Manufacturing*. Center for Security and Emerging Technology. https://doi.org/10.51593/20210024
19. *International trade—Trade in goods and services—OECD Data*. (n.d.). TheOECD. Retrieved May 19, 2022, from http://data.oecd.org/trade/trade-in-goods-and-services.htm
20. Kiisler, A., Solakivi, T., & Hilmola, O.-P. (2020). Supply Chain and ICT Issues of Estonia: Survey Findings. *Procedia Computer Science*, *176*, 828–837. https://doi.org/10.1016/j.procs.2020.09.078
21. Lemola, T., & Lovio, R. (n.d.). - *POSSIBILITIES FOR A SMALL COUNTRY IN HIGH TECHNOLOGY PRODUCTION THE ELECTRONICS INDUSTRY IN FINLAND*. 32.
22. Liu, M. D., Yujing. (n.d.). *'Made in China 2025': How Beijing is boosting its semiconductor industry*. South China Morning Post. Retrieved April 30, 2022, from https://multimedia.scmp.com/news/china/article/2165504/china-2015-semiconductors/index.html
23. Ltd, P. M. R. P. (n.d.). *Global Consumer Electronics Market to Reach US$ 2.9 Trillion by 2020—Persistence Market Research*. Retrieved April 21, 2022, from https://www.prnewswire.com/news-releases/global-consumer-electronics-market-to-reach-us-29-trillion-by-2020---persistence-market-research-609486755.html
24. Luo, Y. (2022). Illusions of techno-nationalism. *Journal of International Business Studies*, *53*(3), 550–567. https://doi.org/10.1057/s41267-021-00468-5
25. M, K. P., & V, S. (2022). *Compendium of Management Case Studies*. Clever Fox Publishing.
26. Machado, V. C., & Duarte, S. (n.d.). *Tradeoffs among Paradigms in Supply Chain Management*. 6.
27. Makarychev, A., & Wishnick, E. (2022). Anti-Pandemic Policies in Estonia and Taiwan: Digital Power, Sovereignty and Biopolitics. *Social Sciences*, *11*(3), 112. https://doi.org/10.3390/socsci11030112
28. Maslarić, M., Backalic, T., Nikolicic, S., & Mirčetić, D. (2013). Assessing the trade-off between lean and resilience through supply chain risk management. *International Journal of Industrial Engineering and Management*, *4*, 229–236.
29. Mudambi, R. (2008). Location, Control and Innovation in Knowledge-Intensive Industries. *Journal of Economic Geography*, *8*, 699–725. https://doi.org/10.1093/jeg/lbn024

30. *My kingdom for a chip: The semiconductor shortage extends into 2022*. (n.d.). Deloitte Insights. Retrieved May 18, 2022, from https://www2.deloitte.com/xe/en/insights/industry/technology/technology-media-and-telecom-predictions/2022/semiconductor-chip-shortage.html
31. Pank, E. (2022). *The Estonian Competitiveness Report 2022*. 47.
32. Peters, M. A. (2019). Trade wars, technology transfer, and the future Chinese techno-state. *Educational Philosophy and Theory*, *51*(9), 867–870. https://doi.org/10.1080/00131857.2018.1546109
33. Pettit, T. J., Croxton, K. L., & Fiksel, J. (2019). The Evolution of Resilience in Supply Chain Management: A Retrospective on Ensuring Supply Chain Resilience. *Journal of Business Logistics*, *40*(1), 56–65. https://doi.org/10.1111/jbl.12202
34. Ravi, S. (2021, August 2). *Global Semiconductor Sales Increase 29.2% Year-to-Year in June; Q2 Sales Up 8.3% Over Q1*. Semiconductor Industry Association. https://www.semiconductors.org/global-semiconductor-sales-increase-29-2-year-to-year-in-june-q2-sales-up-8-3-over-q1/
35. Simatupang, T. M., Wright, A. C., & Sridharan, R. (2002). The knowledge of coordination for supply chain integration. *Business Process Management Journal*, *8*(3), 289–308. https://doi.org/10.1108/14637150210428989
36. *Smart Electronics from Estonia_2019_*. (n.d.). Retrieved May 12, 2022, from https://online.fliphtml5.com/qxzls/shil/#p=18
37. *Statistical database—Select table*. (n.d.). Retrieved April 27, 2022, from https://andmed.stat.ee/en/stat
38. Studies, A. I. for P. (2021). *Technology Competition and the Challenges of Rebuilding* (Rebuilding, pp. 108–115). Asan Institute for Policy Studies. http://www.jstor.org/stable/resrep39829.15
39. *Understand ODM, OEM, OBM [Explained With Examples] | Difference*. (n.d.). Starlity. Retrieved April 27, 2022, from https://www.starlity.com/post/odm-obm-oem
40. Voas, J., Kshetri, N., & DeFranco, J. F. (2021). Scarcity and Global Insecurity: The Semiconductor Shortage. *IT Professional*, *23*(5), 78–82. https://doi.org/10.1109/MITP.2021.3105248
41. Yang, L. W., Ping, L. Y., & Nan, Q. C. (2010). Research on self-directed innovation path from OEM to ODM, OBM in enterprise. *2010 International Conference on Logistics Systems and Intelligent Management (ICLSIM)*, *3*, 1847–1850. https://doi.org/10.1109/ICLSIM.2010.5461319
42. Zhang, A., & Huang, G. Q. (2012). Impacts of business environment changes on global manufacturing outsourcing in China. *Supply Chain Management: An International Journal*, *17*(2), 138–151. https://doi.org/10.1108/13598541211212889

Appendix A

Trade data from Jan. 2018 to Jan. 2022

Table 5.
Top 20 exports and imports of goods by Flow, Commodity (by HS CN8541), Country, Indicator and Reference period, commodity value, rounded in thousand euros

	CN China	MY Malaysia	JP Japan	TH Thailand	TW Taiwan (CN)	PH Philippines	KR South Korea	VN Vietnam	IN India	ID Indonesia
2018 January	732	207	114	222	115	28	27	87	4	29
2018 February	1010	595	92	102	60	54	59	258	4	22
2018 March	943	286	199	79	82	77	7	305	2	0
2018 April	758	238	144	226	99	404	20	6	3	14
2018 May	942	305	134	88	94	365	31	80	132	16
2018 June	762	342	154	79	181	126	16	158	1	8
2018 July	753	334	180	179	161	103	34	602	184	9
2018 August	822	367	147	296	553	217	41	203	47	26
2018 September	675	348	161	490	372	144	63	4	161	11
2018 October	1788	595	394	218	425	113	48	1558	30	35
2018 November	2147	746	308	435	693	115	62	120	160	8
2018 December	1738	615	180	155	217	64	62	1	98	16
2019 January	14693	5635	1602	1620	1256	995	1014	871	647	238
2019 February	1202	540	203	165	72	249	123	12	5	17
2019 March	777	569	212	83	89	99	76	52	278	11
2019 April	1044	476	184	194	132	123	120	2	1	21
2019 May	1495	321	184	98	73	101	54	225	92	21

2019 June	1707	450	175	231	133	93	96	1	1	38
2019 July	918	488	149	98	146	73	128	2	33	8
2019 August	1342	592	103	128	45	38	57	2	122	30
2019 September	1920	585	70	144	157	49	61	149	92	9
2019 October	1157	258	65	129	73	79	25	303	5	9
2019 November	1051	321	69	155	148	29	93	117	2	35
2019 December	975	523	70	118	62	18	87	2	0	16
2020 January	1105	513	117	78	127	44	95	3	15	24
2020 February	60673	2877	2471	1820	2231	780	981	518	232	326
2020 March	1196	361	189	236	86	27	169	34	9	26
2020 April	944	190	61	107	59	62	19	148	3	16
2020 May	1644	197	158	154	57	70	21	2	5	21
2020 June	1558	166	109	119	64	59	24	15	2	32
2020 July	2649	207	139	199	40	72	47	202	112	3
2020 August	3712	181	123	161	67	64	39	75	11	46
2020 September	6222	222	142	287	53	75	92	0	6	47
2020 October	8687	239	95	99	234	74	80	4	0	16
2020 November	6333	250	210	89	130	97	138	3	50	9
2020 December	9019	457	953	145	509	68	115	3	29	62
2021 January	8794	198	105	85	712	50	138	1	4	19
2021 February	9914	208	186	138	220	63	98	30	2	29
2021 March	21701	13777	2460	1440	1165	1384	1260	36	327	318
2021 April	1248	303	142	69	74	49	93	3	3	67
2021 May	794	285	196	61	40	62	122	10	12	27
2021 June	1445	282	148	74	75	118	121	3	5	9

2021 July	1287	295	138	99	117	84	36	2	4	10
2021 August	1759	356	152	137	136	74	85	1	8	23
2021 September	2124	373	234	81	104	111	82	5	5	6
2021 October	1791	387	262	62	148	162	124	2	6	9
2021 November	2414	423	213	310	86	123	132	3	7	22
2021 December	2254	342	267	139	79	60	166	2	109	27
2022 January	1298	10157	283	170	81	182	52	0	162	27

Source: Statistic Estonia

Appendix B

Interview Questions

1. What percentage of the company's total supply chain costs do semiconductor components account for?

A. Less than 5%

B. 5% to 10%

C. From 10% to 50%

D. Over 50%

2. What is your position in the company?

A. Senior-level manager

B. Manager of the supply chain

C. Other positions

3. Considering the trade-offs between risk and cost in the supply chain (as shown in the Figure 5), how would you describe your company's supply chain strategy?

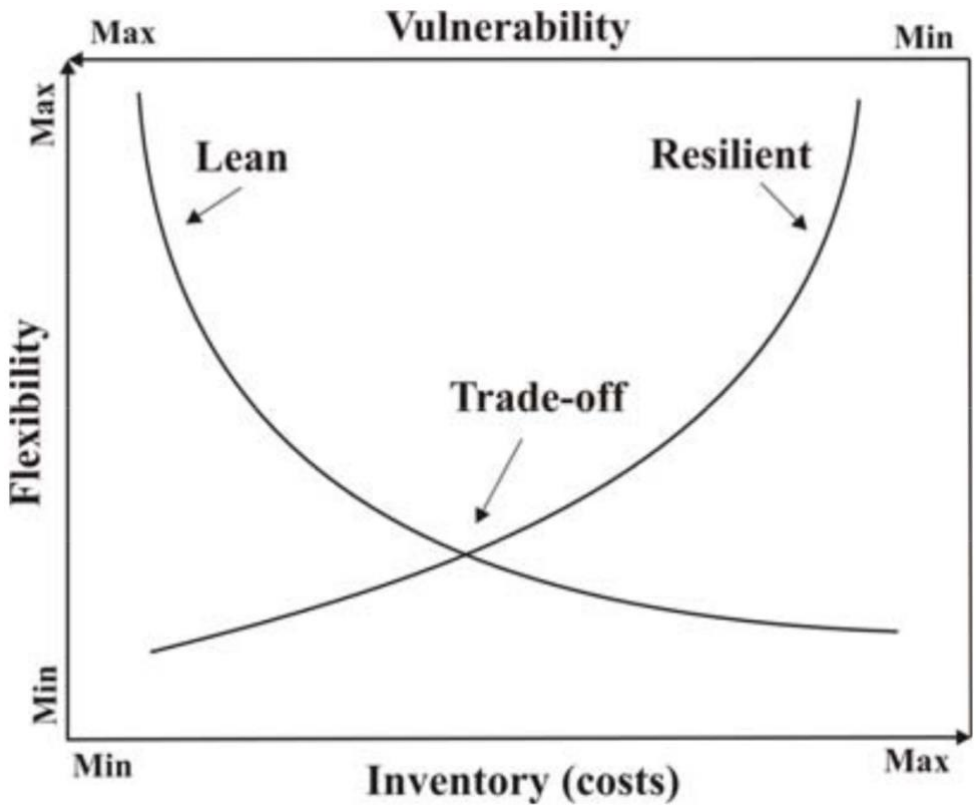

Figure 5. Trade-Off Between Risk and Cost in the Supply Chain

Source: Maslarić et al., (2013)

A. Risk aversion (high cost, high supply chain resilience, low risk)

B. Risk seeking (low cost, low supply chain resilience, high risk)

4. What actions did your company take with your components in terms of countries of origin before the trade turbulence (for example, before 2018)?

A. We depended on one single source.

B. We were actively in search of more possible supply channels (like China Plus One) while highly depending on one single source. China Plus One, also known simply as Plus One, is a manufacturer wishing to diversify its sources of production away from the world's second-largest economy, which is currently locked in a trade dispute with the United States.

As businesses seek to wean their dependence on China, moves towards diversification seem probable (China-Plus-One Strategy - CME Group, n.d.).

C. We were dynamically cooperating with multiple trading partners from different countries.

5. What is the current action that your company is taking with your components in terms of countries of origin?

A. We depend on one single source.

B. We are actively in search of more possible supply channels (like China Plus One) while highly depending on one single source.

C. We are dynamically cooperating with multiple trading partners from different countries.

6. What best describes the future strategy regarding the countries of origin?

A. We are retaining the same supply chain management strategy as we implemented before.

B. We are considering the China Plus One strategy in Asia while maintaining the current supply chain in China.

C. We are nearshoring our supply chain (for example, other European countries). If yes, which country specifically, and why?

D. We are procuring locally

7. What is (are) the reason (s) your company is switching from China to other LLCs (Low-Cost Countries)?

A. The limited supply capacity of China's semiconductor industry.

B. Growing labor cost.

C. High logistics cost.

D. Strict covid policy in China, which causes instability of supply chain.

E. Other reasons (please specify).

8. Are there any other company-level reasons that you would like to add that led to the changes? Why?

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