LUISS

Corso di laurea in Global Management & politics

Cattedra di Managerial economics

Challenges and opportunities for Italian SMEs in the global Semiconductor Market: An empirical analysis

Relatore: Prof. Andrea Filippetti
Correlatore: Prof. Chiara Felli

Candidato: Simone Fusco 762041

Anno Accademico 2023/2024

Table of Contents

INTRODUCTION

CHAPTER 1: THE GLOBAL VALUE CHAINS

1. What are GVCs

2. Historical development of the concept of GVCs

3. The Second Unbundling of Globalization

3.1 Stages of Unbundling

4. The Smiling Curve Theory

5. The Small and Medium Enterprises (SMEs)

6. Case Study: Diesel and the Upgrading in GVC

7. The chip sector and research question

CHAPTER 2: THE CHIP SECTOR

1. The Production Disparity

2. The Chip COVID Crisis

3. Market Barriers Analysis

3.1 Entry Barriers for SMEs

3.2 Innovation and Internationalization barriers

3.3 Supply Chain Barrier

4. The Chip Production Phases

4.1 Design Phase

4.2 Manufacturing Phase

4.3 Assembly and Testing Phase

5. The Three Manufacturing Approaches

5.1 Fabless

5.2 Integrated Device Manufacturer (IDM)

5.3 Foundry

6. The Public Intervention: European and Italian Chip Acts

6.1 Practical implementation of the European chip act

CHAPTER 3: THE ITALIAN MARKET OF SEMICONDUCTOR

1. The Italian Panorama

2. The Italian Firms

3. Clean Rooms in Italy

4. Foreign Companies

CHAPTER 4: RESEARCH STUDY

1. Italian SMEs

2. The pool selection

3. Firms interviewed

4. Interview modality and text

5. Section analysis

6. Final reflections

Conclusions

Limitations and future developments

Bibliography

INTRODUCTION

Over recent decades, global value chains (GVCs) have become a key factor in understanding the shifting dynamics of the global economy. GVCs allow firms to fragment the production process into many stages, which can be highly dispersed over different geographic regions, allowing firms to exploit local capabilities and resources. This has drastically changed the manufacturing process, particularly in technologically advanced sectors such as semiconductors, characterized by high-value-added products whose production is distributed worldwide.

The idea for this study comes from the recent debates around the topic of semiconductors, which arose in the wake of the COVID chip crisis and the release of "Chip Wars", by Miller (2022). This book had a major impact by showing the economic and strategic importance that semiconductors have acquired in modern economies. The purpose of this analysis is to focus on the investigation of the semiconductor GVC, which has been the fastest-growing industry over the past 30 years (Miller, 2022) and has become a central pillar of the global economy. It is estimated that approximately 70% (Miller, 2022) of the global economy is influenced by chips, as they have become omnipresent across all industries, including telecommunications, automotive, defense, and consumer electronics. The semiconductor GVC gives Italian small and medium enterprises (SMEs) new opportunities, at the cost of many challenges that they must face. While Italy is not a major producer of semiconductors, this study wants to understand in which niche the Italian SMEs can specialize.

The final goal is to comprehend how Italian SMEs work with the GVC of the semiconductors, what is their role, what are their strategies and difficulties, and how they can overcome them. The research question is:

How can Italian SMEs in the chip sector optimize their participation in Global Value Chains to maximize economic and technological benefits, overcoming existing barriers?

With this study I want to give my contribution to the recent debate around semiconductors, giving an in-depth analysis of the SMEs' market of the country. To reach this goal I will make use of semi-structured interviews that will be proposed to the most important Italian semiconductor SMEs.

The first chapter introduces the concept of GVCs with a literature review, giving a clear definition and outlining factors that drove their expansion, such as technological advances and the reduction of trade barriers. It gives a historical analysis, analyzing the evolution of the concept over the years. Then, it observes international studies about the relationship between SMEs and GVC, underlining the most critical factors and giving practical examples. After the theoretical disquisition about GVC, the second chapter is dedicated to the semiconductor industry; it analyzes all the steps of chip production and the structure of the GVC, investigating the companies that composes it, the geographical distribution of the production and the fragilities of the GVC with the COVID-19 pandemic crisis as a case study. Lastly, the chapter gives some insight regarding the recent European Chips Act, explaining how the new investment could help the sector and the SMEs that take part in the production of chips.

Chapter III moves the attention to the Italian context. Even though Italy is not an important producer of the sector, there are some important companies such as STM and some niche competencies, particularly regarding the production of special machinery and research and development; nonetheless, there are many limits in the Italian semiconductor Industry that are highlighted, such as the general lack of formation in the sector and investment on research. The chapter will further explore the current initiatives, such as the Chips.it platform, and how these are planning to reinforce Italy's competitive position in the sector.

Lastly, the fourth chapter is the core of the study as the empirical research, based on interviews with the selected 6 Italian SMEs, will be presented. Through these interviews, challenges faced by these companies will be explained and clarified, giving attention to the strategies they adopted to integrate into GVCs, with particular attention to market access, innovation, and the opportunities created by policies such as the European Chips Act.

The thesis concludes with the interpretation of the outcomes of the empirical analysis and provides a few recommendations for the Italian SMEs. The last section is dedicated to a discussion regarding the Italian market and the potential future developments.

CHAPTER 1: THE GLOBAL VALUE CHAINS

1. What are GVC?

Global Value Chains (GVCs) are international production networks that allow companies to break down the production process into different stages that are carried out in different regions, thereby optimizing costs and production efficiency. Each region of the world contributes its own resources and capabilities to the production process. GVCs have now become the core of the modern economic system (Antràs & Chor, 2022). Since the 1980s, the international trade landscape has undergone profound changes due to advances in communication technologies and the reduction of trade barriers, facilitated by numerous free trade agreements, most notably China's entry into the World Trade Organization in 2001 (WTO, 2010). These developments have resulted in a considerably more complex production system, causing the production process to become so intricate that sometimes it is difficult to determine where a product has been produced.

Global Value Chains (GVCs) have had a significant impact on the international production system, catalyzing extensive industrialization and allowing large multinational companies to expand, becoming more efficient and capable of meeting the increased global demand for goods and services. However, the impact of GVCs on the economy of individual states raises some concerns. Some studies that will be shown indicate that the role of small and medium-sized enterprises (SMEs) risks being marginal; consequently, the objective of this review is to analyze the concept of the value chain and understand its functioning. This analysis will facilitate an examination of the role that SMEs can play within it and identify the principal points they must consider if they wish to engage effectively with a global chain.

The analysis will begin with a historical review of the concept of Global Value Chains (GVC), subsequently progressing to a more detailed examination of their practical operation and structure. Finally, I will explore the literature regarding Small and Medium Enterprises (SMEs) examining how these firms can engage with this framework, assessing the risks and opportunities by referencing industry studies and case studies.

2. Historical development of the concept of GVCs

Research on Global Value Chains (GVCs) has evolved over the past decades with the establishment of a new theory. Many theorists have explored how social relationships,

institutions, and technology shape global value chains. The growth of these theories led to a deeper understanding of firm production dynamics and a new way to examine the global economy.

In his influential 1985 work, "Economic Action and Social Structure: The Problem of Embeddedness" (Granovetter, 1985), Mark Granovetter explores the concept of embeddedness, arguing that economic actions are inherently linked to networks of social relationships. Granovetter distinguishes between weak and strong ties, emphasizing how weak ties are crucial in accessing information and opportunities that are not available within closer circles characterized by strong ties, which, instead, provide support and resources. This approach challenged the notion of a purely rational and isolated market, highlighting the significance of human connections in facilitating or hindering economic operations. (Granovetter, 1985). Shortly after Granovetter's theories emerged, Douglass North's book "Institutions, Institutional Change, and Economic Performance" (North, 1990) investigated how both formal and informal institutions influence economic conditions. According to North, institutions play a critical role for economic stability and in lowering uncertainty with a significant impact on the conduct of enterprises inside GVCs. His work took the idea of embeddedness to the macro level, connecting governance and cultural norms to nations' economic performance and capacity to successfully engage in global commerce.

In their work "Commodity Chains and Global Capitalism" (Gereffi & Korzeniewicz, 1994), Gereffi and Korzeniewicz further developed the theory of value chains, examining how goods are produced through complex networks that connect various countries. Their analysis led to a deeper understanding of the structure and dynamics of GVCs: they successfully showed how the flow of goods, services, and information across international borders is coordinated to maximize efficiency and reduce costs.

Indeed, studies on commodity chains were already present between the 1970s and '80s, analyzing how goods were produced and traded across international borders (Hopkins & Wallerstein,1986). The pioneering studies by sociologists and geographers such as Terence Hopkins and Immanuel Wallerstein explored commodity chains within the context of the world-system, laying the groundwork for understanding global interconnections in terms of production and trade. However, the analysis of Gereffi & Korzeniewicz (1994) highlighted the complexity of global economic interactions and the importance of strategic positioning

within production networks. What distinguishes this analysis from previous ones is the shift in focus from goods production to the concentration of power. Gereffi primarily identifies two types of structures in commodity chains:

- Producer-driven chains are dominated by producers, typically large multinational corporations that control upstream production and product design. Common examples include the automotive and electronics industries, where large corporations hold significant control over production processes and innovation.
- Buyer-driven chains: In these chains, power is concentrated in the hands of large retailers, brands, and distributors. These actors control production networks through their ability to order large volumes and influence product designs and specifications. Typical examples include the apparel and consumer goods sectors, where large retailers like Walmart or Zara play a key role.

3. The Second Unbundling of Globalization

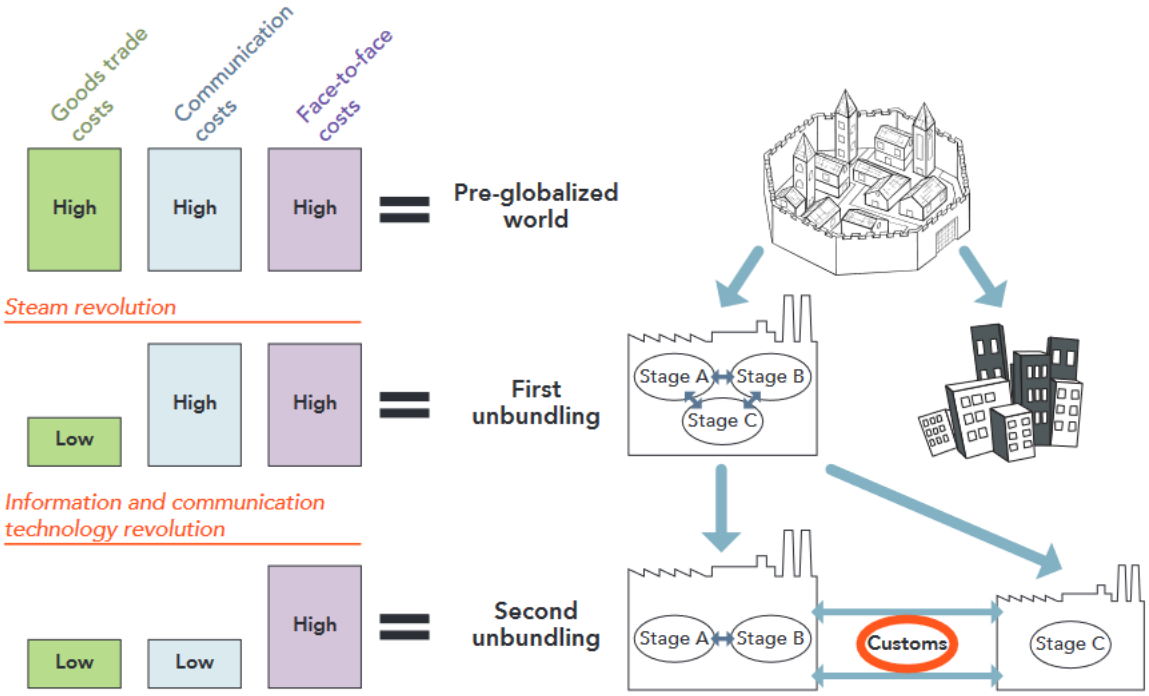
The expansion of information and communication technologies (ICT) and the liberalization of global trade in the 1990s accelerated the integration of global economies, making the concept of GVC increasingly relevant. Companies began to fragment their production operations into different locations to exploit local competitive advantages such as lower labor costs, access to specific resources, and tax benefits. Thus, the concept of the second unbundling occurred (Baldwin, 2016).

Richard Baldwin's book "The Great Convergence: Information Technology and the New Globalization" (2016) further expanded the debate around GVCs: he emphasized how information technology had been a transformative force in shaping a new globalization that has allowed for the geographical dispersion of the various phases of manufacturing; a factor increasing the possibilities for SMEs to join GVCs. This has accelerated economic integration at the global level and hence altered the way in which enterprises coordinate and manage output at a world level.

3.1 Stages of Unbundling

GVCs, analyzed in detail in Richard Baldwin's 2016 studies, have evolved from simple supply chains to complex global networks. Baldwin highlighted two stages of “unbundling”:

- First unbundling: Driven by transportation innovations during the first industrial revolution, which geographically separated production from consumption locations, allowing international trade to expand beyond local communities and leveraging the economies of scale in mass logistics to reduce transportation costs.
- Second unbundling: The fragmentation of production stages across different countries, amplified by the advent of ICT. These technologies facilitated the coordination of production units in various locations, enabling developing countries to integrate into GVCs and achieve industrial growth by exploiting input cost differences between countries.



Picture 1: first and second unbundling. (Satoshi Inomata, 2017)

The second unbundling completely transformed the GVC functioning by optimizing the whole value chain by promoting specialization in areas with better efficiency or competitive advantages. The division of labor has been encouraged on a global scale by the recent global economic integration, which has been aided by the removal of trade barriers and technology advancements, optimizing the use of resources and talents worldwide. Today, GVCs dominate production in many industries, as evidenced by the automotive industry, Car companies, such as Toyota, Ford, and Volkswagen, adopt a production model

in which the various car components are made in different parts of the world (Sturgeon et al., 2008). For example, a car may have the engine produced in Germany, the electronics developed in Japan and the interior assembled in Poland, before everything is finally assembled in a factory in the United States or Mexico.

With this strategy, each area may focus on certain industrial specializations. For example, Silicon Valley contributes advanced information technology for navigation and security systems, while Italy is renowned for producing high-quality design parts for interiors (Bettiol et al., 2022). This specialization not only increases production efficiency but also improves vehicle quality, offering consumers improved final products through the combination of the best global expertise at the most competitive price.

4. The smiling curve Theory

GVCs are theoretical constructs that describe how productive forces interact in the real world, but how do they truly operate? A famous model that attempts to represent the different key stages in the production process is the "smiling curve".

The "smiling curve" is a conceptual model developed in the manufacturing and technology sectors to describe the distribution of added value along a product's supply chain. This model was first introduced by Stan Shih (1996), the founder of Acer Inc., in 1992. According to the smiling curve, the stages of product design and development (upstream) and marketing and after-sales services (downstream) are associated with higher added value compared to the actual production phase, which is commonly subject to low profit margins and intense competition. This phenomenon is explained by the greater difficulty of replicating specialized skills and specific knowledge present in the upstream and downstream stages of the chain, in contrast to production, which can be easily standardized and automated (Shih, 1996). Subsequent studies have extended the concept of the smiling curve to the service and information sectors, where the ability to generate value is significantly influenced by innovation and customization (Chang & Grubb, 2012). Furthermore, this model has led to discussions on the importance of innovation and brand equity as defenses against commoditization in high-tech industries (Lee & Grewal, 2014).

The model remains relevant in understanding how companies can strategically position themselves to maximize the added value of their activities in the GVC. During the production of a good, there are different stages (Mudambi, 2008): design and development,

raw material collection, production, distribution, sales, and after-sales service. Within this process, the goods gain value and go from a raw material with little added value to a final product with high added value that allows the company to have a higher margin. Production process consists of several interconnected phases, each contributing its own added value. The R&D (Research and Development) phase is crucial for product innovation and design. This phase brings high added value because it determines the fundamental characteristics and functionalities of the product. R&D is often located in countries with a strong background in technical education and good research infrastructure. (Fuchs,2022)

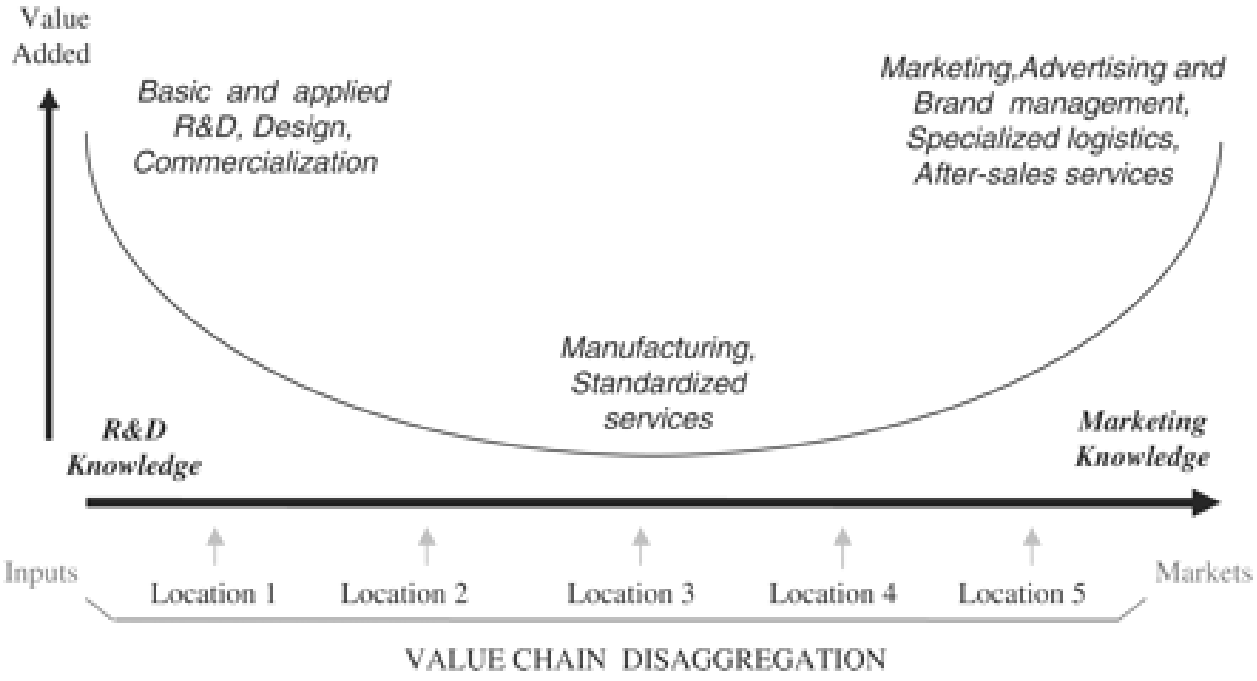
Following R&D is the Original Design Manufacturing (ODM) phase, where a company designs and manufactures a product that will be marketed by another company. This is a very specialized and highly valuable phase, since design deals not only with aesthetic appeal but also with the functionality and usability of a product. Then comes the production stage, where either specific component is made by Original Equipment Manufacturers or OEMs. These firms produce components or a whole product that is sold under another company's brand. Here, the value addition is essential in efficient and cost-effective production. (Fuchs,2022)

Next is the assembly phase, where the individual components are brought together to form the final product. Although this stage may be less specialized than others, its efficiency is critical for reducing production costs and enhancing the overall quality of the final product. Once assembled, the goods enter the distribution phase, which involves the logistical management of transporting the finished products from production sites to end markets. In this phase, value is derived from the optimization of logistics processes and the reduction of delivery times. (Fuchs,2022)

Marketing then plays a decisive role, positioning the product in the market and shaping the brand's identity. This phase is essential, as the perceived value of the product is closely tied to how it is presented and promoted to the target audience. Finally, after-sales services, including technical support, maintenance, and other customer-oriented services, further enhance the product’s value. These services not only improve the customer experience but also foster customer loyalty and help differentiate the brand in a competitive market. (Fuchs,2022)

Baldwin (2016) points out that the distribution of value added along the GVC is not uniform and depends on many factors, including the complexity of the technology deployed, government policies, infrastructure capacity and available workforce. Furthermore, the evolution of ICT and the lowering of coordination costs have allowed for a greater geographical dispersion of these steps, each of which can be optimized to exploit specific advantages of different national or regional contexts.

The picture 2 illustrates the smiling curve and its incremental value added by each stage. The highest-value processes are those related to research and development and services, while production appears to provide less value despite its essential nature.



Picture 2: the smiling curve (Mudambi, 2008)

Depending on the sector and the commodity being processed, different GVC modes can take shape (Satoshi Inomata, 2017). For example, for goods of a generic nature, which do not require investment in specific production facilities, a market-type value chain often develops where manufacturers and acquirers have a wide variety of choice of trading partners.

However, in cases where the manufacturing process involves specialized equipment, the transaction between the companies becomes asset-specific, and the parties become

dependent on each other; this is the case with the coffee chain (Fei Cui Overbeek,2023), perhaps one of the most globalized and representative markets for GVCs. Coffee production takes place on plantations in tropical countries such as Vietnam Colombia and Ethiopia where the beans are grown and harvested, then fermented washed and dried, after which they are sent to consuming countries where they are further roasted, roasting takes place close to the selling market to ensure the freshness of the product, and finally the roasted coffee is shipped to wholesalers and retailers to be consumed. This simple chain allows us to analyze how efficient GVCs are in creating value by exploiting the competitive advantages of individual countries.

Depending on the power disparities within the value chain, captive value chains or hierarchical value chains can also be configured, in cases of strong asymmetries in power within the chain, which is obviously the case of markets led by multinational giants that drive production, forcing smaller producers to follow them and their decisions.

5. The small and medium enterprises

After analyzing the historical development and the theoretical fundings of the GVCs now it is essential to investigate how SMEs, the core of this study, can interact with this production system: is it really a threat they must defend against, or can they exploit the advantages that GVCs offer to their benefit?

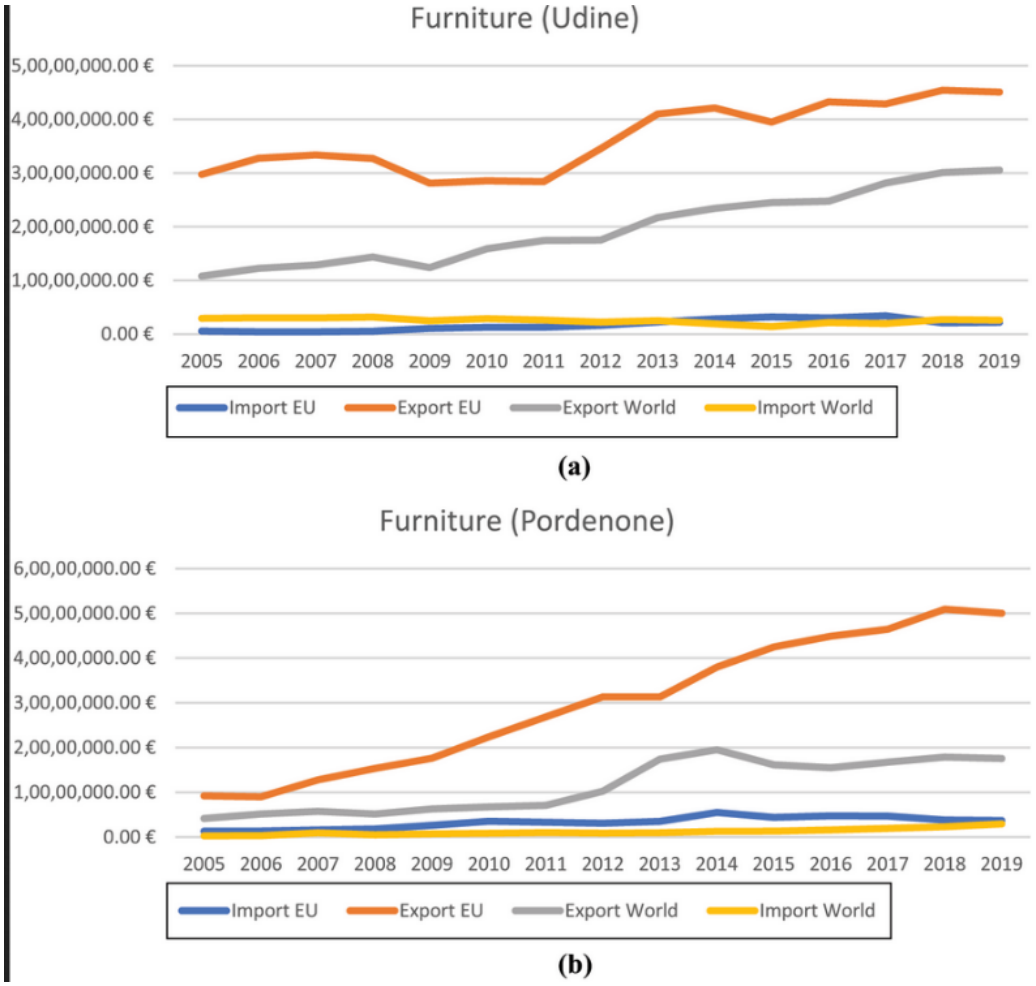
In addressing this question, a report by the Asian Development Bank (2015) provides interesting details on the challenges SMEs face, particularly regarding access to the financing needed for modernization. Non-financial difficulties include limitations in management and technological innovation, which hinder access to international markets. Proposed solutions include financial support schemes with soft credit and programs to develop technical and managerial skills, aiming to stimulate an innovative environment. This would involve government intervention to provide SMEs with the necessary tools to modernize and compete effectively in the high value-added sectors of GVCs, such as R&D and advanced service provision. This approach could enable SMEs to overcome their subordinate status relative to large companies and become significant players in the international arena.

SMEs struggle to compete at the same level with the multinational corporations that rule the global value chain, they often find themselves forced to operate 'in the shadow' of the

large companies that dominate the value chains (Sinkovics et al., 2021). Due to their small dimension, SMEs cannot take advantage of the economies of scale available to multinationals and often occupy disadvantaged positions in purchasing processes. The paper by Sinkovics highlights the difficulties of SMEs in receiving recognition from large players and having to adapt to high and costly standards to collaborate with them, resulting in poor participation in the decision-making processes of large companies. Often a hierarchical GVC takes shape in which the leading company guides the production of the companies that become satellites.

Despite these obstacles, some schools of thought argue that SMEs can find ways to interface with and benefit from GVCs. For instance, by focusing strongly on research and development (R&D) and becoming specialized companies, they can successfully integrate into GVCs. In this sense, the Antràs and Chor study (2022) provides a detailed analysis of how SMEs integrate into GVCs. What emerges is that the SMEs that participate the most tend to be larger in size, have greater production capacity and a strong inclination towards innovation and exporting. It is suggested that flexible business practices and trusting relationships between producers and buyers can facilitate the integration of companies into GVCs. SMEs can thus thrive by exploiting the interconnection of GVCs by specializing in specific tasks within the value chain, exploiting their specific competencies, which may be advanced manufacturing skills or specialized product knowledge (Bettiol et al., 2022).

GVCs are therefore not only a threat for small companies but can be a great opportunity to access the global economy, GVCs make up 84% of the international production networks of multinational companies (UNCTAD, 2017) providing a great opportunity for small companies to access new markets and alternative sources of capital. We have an example of this in Italy, where industrial districts in the north-east specializing in furniture and fashion have exploited their specific manufacturing knowledge to enter GVCs and access international markets, which they have then used to drive innovation and upgrade their manufacturing processes (Bettiol et al., 2022). This allowed them to invest in higher value-added activities such as design and branding, thus improving their position and value captured in global value chains. The picture 3 shows how exports grew in the furniture sector during las years, witnessing the good job made by the Italian firms in this sector.



Picture 3: Trend of imports and exports of furniture from EU and worldwide by sector and year, (a) Udine, (b) Pordenone (Bettiol et al., 2022).

6 Case Study: Diesel and the concept of Upgrade in GVC.

To better understand how a small firm can exploit the network advantages of a GVC by improving its positioning in the market, I decided to analyze the case study of Diesel S.p.A. started as a small Italian firm now become a multinational company that sells all over the world.

Diesel S.p.A., founded in 1978 by Renzo Rosso in Veneto, Italy, (Diesel®, n.d.) is a company that has transformed itself from a small clothing business into one of the most worldwide recognized lifestyle brands. Known for its denim and its innovative marketing approach, Diesel has embraced a global strategy that combines Italian design, creative marketing, and international distribution.

Diesel effectively exploited the Global Value Chains to enhance its position in foreign markets. Their business approach combined in-house production with outsourcing, allowing the company to strengthen its supply chain while maintaining high standards for its goods and quickly expanding its distribution network. The ability to control various aspects of production and marketing within GVCs has allowed Diesel to maintain a strong and cohesive brand identity, a crucial aspect of its global success (Keller, 2008). Diesel's strategy has always been based on innovation in their product design and promotional activity. This company has often adopted original marketing techniques that raised both customers' and media's interest, which consolidated its "rebel" brand identity. This approach has allowed Diesel to differentiate itself in a crowded market and enhance its positioning within GVCs (Okonkwo, 2007). With the growth of digital technology, Diesel has promoted new techniques through which manufacturing and marketing have been developed. Since Diesel was among the first companies that employed e-commerce and social media from an early stage, it has enlarged its audience worldwide and communicated directly with its customers. It thus can respond quicker to any market events and changes in consumer preferences. This digital strategy has seamlessly integrated into its GVC operations, optimizing distribution and product customization (Berman & Thelen, 2018).

Despite its success in the long run, the firm had to face many obstacles in its path. market saturation and strong competition between other luxury brands and fast fashion retailers.

The company had to find a way to balance these factors with a constant trade-off between innovation, brand management, and the responsiveness to changing market conditions. Diesel experience clearly shows how investment in key areas of the smiling curve determines SMEs' ability to enter the interconnection of GVCs, throughout its history, the company successfully invested in the high-value-added stages of production: innovation, design, marketing, and distribution.

Diesel's example can also illustrate how SMEs can effectively leverage the concept of "upgrading" in Global Value Chains (GVCs) (Humphrey & Schmitz, 2002) to improve their competitive position in the global market. The notion of "upgrading" in global value chains is critical to understanding how businesses might improve their market position. Companies upgrade their capabilities, processes, and products to move up the GVCs' value chain. This concept emerges from the studies of economists John Humphrey and Hubert

Schmitz (2002), who identified four main types of upgrading: process, product, functional, and chain upgrading. Each type belongs to specific modality of improvement: from enhancing production efficiency (process upgrading), to developing more sophisticated and valuable products (product upgrading), to moving to higher value-added functions like design and marketing (functional upgrading) and shifting to more profitable or technologically advanced production chains (chain upgrading). Through this theoretical framework, we can analyze Diesel Spa's moves in more detail.

Applying the lenses of the upgrading theory to the Diesel case shows that the early introduction of e-commerce, for example, is a significant chain and process upgrade, allowing the company to exploit technological innovations while improving its profit margins on its products by selling them directly through its store. The upgrade is also accompanied by a large investment in design marketing and brand identification, elevating the firm to much more than just a denim manufacturer and allowing it to dramatically enhance the margin per product sold. This case study demonstrates how investments on innovation and brand identity may significantly boost a company's status in the worldwide market, giving a vital lesson for SMEs wishing to achieve an effective "upgrade" in the GVC.

7 The chip sector and research question

The GVC dynamics observed are evident in a sector like the semiconductor one, which based its growth on the delocalization and the progressive reduction of the costs that it brought. The sector is highly competitive and technologically advanced: the production of chips requires extremely sophisticated engineering skills, and semiconductor manufacturing facilities can cost as much as 10 billion dollars. (Taiwan Semiconductor Manufacturing Company Limited, n.d.) The design and manufacturing of chips needs specialized knowledge and know-how that are difficult to replicate globally, barriers that are difficult to overcome even for multinational companies. Currently, the semiconductor value chain is highly efficient and specialized but concentrated in specific production clusters (Taiwan, China, Korea), making it challenging to produce them in other regions. However, the significance and strategic importance of this product is encouraging global investments, including the recent European Chip Act (European Commission, 2022) of the EU and the American chip Act of the US with their collaborations with TSMC. (Badlam et al., 2022).

The solid growth of the industry, coupled with the issues observed regarding the relationship between GVCs and SMEs, led me to inquire about the role that Italian SMEs can play in the semiconductor chain, leading to the formulation of the following research question:

"How can Italian SMEs in the chip sector optimize their participation in Global Value Chains to maximize economic and technological benefits, overcoming existing barriers?"

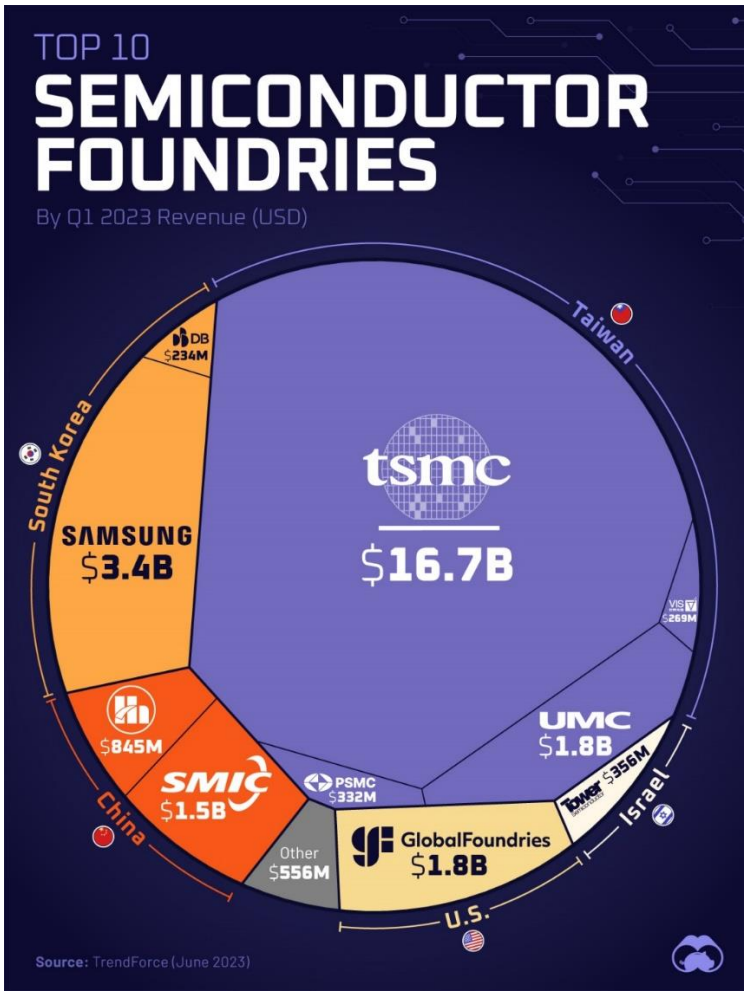
This question is crucial given the strategic importance of the chip market, which is a growing theme of debate due to its centrality to global industrial competitiveness and innovation. Analyzing how Italian entrepreneurial landscapes can integrate into this developing sector will provide valuable insights into the interplay between local capabilities and global market demands. Secondly, Italian SMEs are often recognized for their innovation and flexibility, but they face significant challenges related to scale and resources compared to large multinationals. Understanding how they can effectively integrate and benefit from GVCs could not only improve their economic position but also contribute to the entire national economy through job creation, increased exports, and innovation.

Finally, this question has considerable practical importance. Answering it could provide interesting insights for policymakers and business leaders on how to support SMEs in the chip sector through targeted policies, innovation incentives, and support in negotiating and managing relationships within GVCs. In this way, the research also offers practical tools to enhance a strategic segment of Italy’s position in the global market of semiconductors.

CHAPTER 2: THE CHIP SECTOR

1. The production disparity

In this section I will analyze the microchip production chain, reconstructing the steps that led it to be extremely efficient but very fragile.



Picture 4 (Lu, 2023)

The picture shows the 10 companies with the highest revenue from chip production through their foundries. There is a significant imbalance: TSMC alone holds more than half of the sector's revenue, with other giants like Samsung, despite their importance, remaining marginal players. Most of the global chip production is managed by the Taiwanese giant, which has highly advanced and continually expanding facilities capable of meeting the growing demand for chips (TechNode Feed, 2024). The other companies are not necessarily competitors; over the years, the mechanisms of capitalism and managerial efficiency have led production to be established in locations where labor is cheaper. Until

today, the intensive off shoring of the Silicon Valley caused a huge drop of chips cost, leading towards the creation of the Moore's Law (Miller, 2022) according to which, each generation of chip would double the power of the previous one. This law has been extremely important in the tech industry because it allowed to theorize huge technological advancements and new functions for electronic devices (Miller, 2022), allowing Silicon Valley companies to develop new functions and chip-based products for the mass market. This is why production has shifted from the United States and Japan to Taiwan and China over the years.

It should be clear that although most production is in Southeast Asia, the companies in the sector are all interconnected: TSMC could not produce its chips without the machinery of the Dutch company ASML (Miller, 2022), the only company capable of creating the lithography machines for etching silicon "wafers". Moreover, without the knowledge and designs of companies like Intel (USA), Qualcomm (USA), NVIDIA (USA), ARM (UK) (extremely important for its intellectual properties), or even Samsung (Korea), this production efficiency would be impossible. Additionally, many sensors are produced in Japan, and others in Korea (Miller, 2022); we are in a regime of full interdependence. The market has created this highly efficient system, but as seen with COVID, if one of the central companies in this chain stops (such as TSMC, Global Foundries, or ASML), the house of cards falls, and the market halts: a giant with feet of clay.

However, TSMC's role in this context is undeniably central. Founded by Morris Chang (History and Milestones of TSMC, 2019), the company has arguably become the most important company in the world: both for its revenue and for the dependence the rest of the industry has on it. The products of Samsung, Apple, Intel, AMD, and Nvidia (which produce the processors and video cards in our computers), as well as contracts in the display, automotive sectors, and even with Amazon (Arcuri & Lu, 2022), underscore its significance. Interestingly, this company, central to the entire global economy, is headquartered in Taiwan—a territory China claims as its own and the United States has committed to protect from any Chinese claims.

2. The chip covid crisis

The microchip crisis that occurred in 2021 is perhaps the most accurate example regarding how the production chain works and how fragile it is.

Let's start by describing the context in which the crisis started: It is the 2021, and the world is grappling with the crisis caused by COVID-19, a virus that has resulted in millions of deaths and the interruption of numerous economic activities (Mallah et al., 2021). While COVID-19 plagues the world, causing huge disasters, the microchips that would be incorporated into the iPhone 12 are being produced in Taiwan. The manufacturing process for these chips is 7 nanometers, and the engineers of TSMC are working with dimensions more than a half smaller than COVID-19 (Miller, 2022). This serves to illustrate the complexity and cost of manufacturing a modern processor. In recent years, chip production has increased and evolved significantly. Companies in this sector have specialized through massive investments and have made incredible strides. Engineers at TSMC, Global Foundries, and other industry companies have managed to predict the movement of electrons in very small spaces, thereby significantly increasing the efficiency and reducing the cost of processors (Miller, 2022). The industry that emerged is extremely technical, producing a microchip is not a normal economic activity: it requires huge tech implant, deep knowledge design and study, which TSMC and the other company of the sector reach through several years of development.

But what happens with COVID-19? Due to the pandemic, many of these facilities were forced to close for relatively short periods, but these closures caused massive problems for the production chains of many consumer goods (Miller, 2022). The issue was twofold: on one hand, the production of technological consumer goods slowed down, and on the other, demand significantly increased, as people found themselves confined to their homes during various lockdowns, with technological tools as their only means to communicate and work. This led to a significant increase in demand for these goods, creating a mismatch between demand and supply that took a lot of time to fill. Consider that the PlayStation 5, an extremely popular consumer good, was unavailable for more than a year (Adams et al., 2021), and the console is backed by a large company like Sony, which has a competitive advantage in supply chains compared to smaller companies. The crisis has been very strong and has significantly slowed the growth of the tech sector. However, what makes this crisis unique is that it did not only involve the tech sector. This crisis has made clear how central chips have become to the global economy: the effects were seen in the automotive sector, with orders blocked because the cars required chips to be marketed, but also in household appliances and transportation (Seabolt, 2021). The crisis has slowed all these sectors: in a few years, chips have become central to our economic growth.

The COVID chip crisis has awakened US and EU governments, which have begun to allocate large funds to bring the production of this commodity that has become crucial to our economies back to the West. Currently, huge fundings are planned. President Biden signed the *CHIPS and Science Act*, which allocates around $280 billion in total, including $52.7 billion specifically for the semiconductor industry (Congressional Research Service, 2023). Meanwhile, the EU has approved its own *Chips Act*, which has allocated approximately €43 billion in public and private funding to strengthen its semiconductor sector (European Commission, 2023).

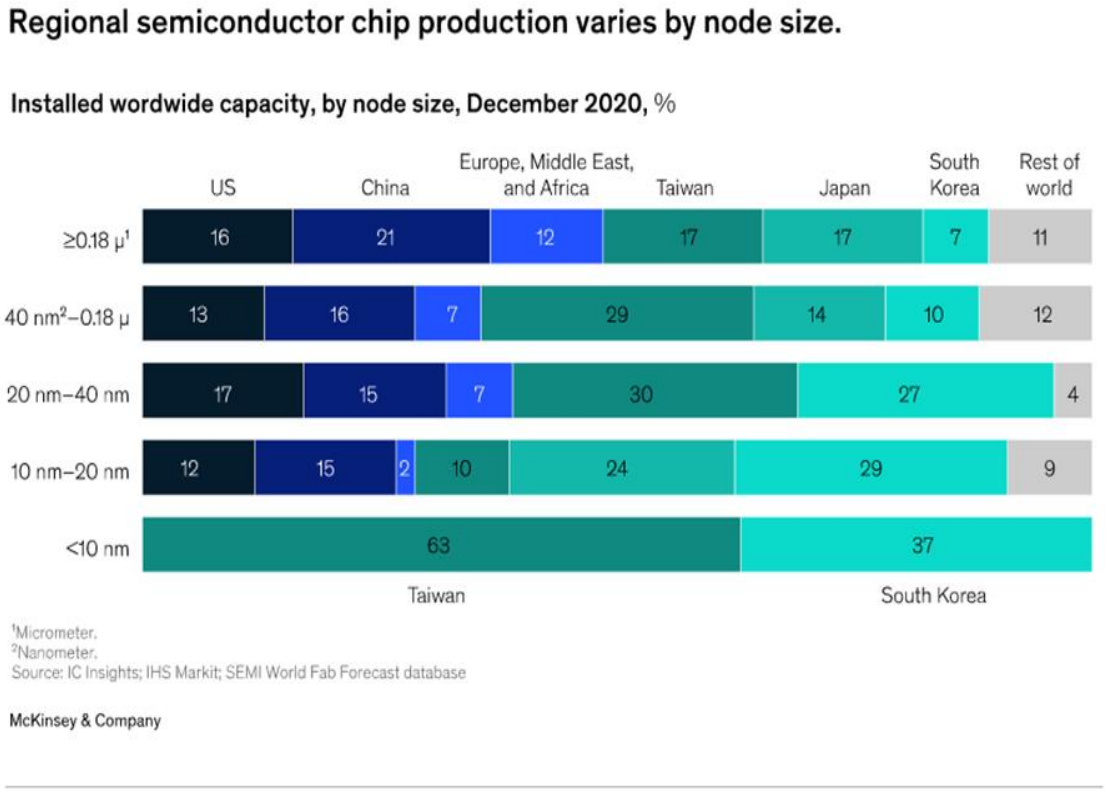
3. Market barriers analysis

It is reasonable to expect a market with such vast private and governmental investment, as well as significant development, to be able to attract many investors and enterprises. However, as seen during the COVID crisis, the market is dominated by a few major firms that possess the technology required, know-how, and financial resources for such large-scale manufacturing. This is because the semiconductor market is highly specialized, with very high entry barriers making it difficult for SMEs to stay competitive. The market exhibits strong entry barriers, preventing new players from accessing, as well as significant limitations on the innovations that SMEs can introduce.

3.1 Entry Barriers

The entry barriers for SMEs in this sector are considerable: Firstly, massive investments are required, building a modern foundry capable of competing with the latest lithographic technologies requires huge costs not achievable by a SME. The challenges do not end there, as specific skills are also essential to keep pace with advanced technological developments, requiring a continuous influx of highly specialized new talent and ongoing R&D activities, which are very difficult for smaller companies. Entry barriers keep getting higher and higher: today, chip production has become extremely complex; only TSMC is currently capable of producing 4nm and 2nm nodes (the most advanced and powerful), which requires enormous investments. Picture 5 illustrates which countries can produce the most advanced chips. It is easy to observe that Italy and Europe are completely out of the production of advanced chips, which is reserved for Taiwan and South Korea. However, this does not mean that European countries cannot carve out a role in the value chain, as exemplified by ASML (“ASML | the World’s Supplier to the Semiconductor Industry”), a

key Dutch company in chip production, renowned for its lithography excellence and innovation-driven success.



Picture 5 (Bartlett et al., 2023)

3.2 Innovation and internationalization barriers

However, being innovative is also more difficult for smaller companies as SMEs' innovation encounters enormous barriers in the sector. Innovation barriers are those that hinder SMEs from continuing to innovate at the pace of larger companies. As mentioned, it is very difficult for a small company to maintain a good inflow of talented and talented workforce. Moreover, a study regarding Spanish SMEs manufacturers (Madrid-Guijarro et al., 2009) shows that financial barriers represent the most significant obstacle for SMEs, which struggle more in raising capital. This significantly limits their innovativeness, especially since, according to the study of Larsen and Lewis (2007) many SMEs choose to ignore these barriers because they have no way to counter them, while others must resort to personal or external capital.

Significant risks for SMEs also include the internationalization of activities. Changes in regulations seem to be the strongest risk for SMEs (Roy et al., 2016), as SMEs are

particularly vulnerable to fluctuations in exchange rates and complex export and import regulations, which can vary significantly from country to country. Large companies can often better manage these risks through hedging strategies and a better ability to negotiate with banks and financial institutions. The Roy's paper also discusses challenges related to the scalability of operations, highlighting that SMEs may struggle to expand production and distribution to meet foreign market demands without compromising quality or service levels.

3.3 The supply chain barrier

Perhaps the largest barrier to accessing the semiconductor markets lies in the inability of SMEs to optimally utilize supply chains. This type of barrier significantly affects even large producers that are not market leaders. Integrating into established supply networks can be difficult, with large companies often controlling access to essential materials and technologies. For instance, industry leaders like Apple can impose on other producers because they are the first to place orders in the value chain and secure direct agreements with manufacturers: e.g., Apple and TSMC (Cunningham, 2023). During the crisis caused by COVID, Apple was able to secure supplies for its products first, leaving other manufacturers like NVIDIA and SONY (PS5), which are big players, in severe difficulty. This barrier is very significant and reflects a strong power imbalance within the GVC, which is hierarchical in nature. The largest companies, like Apple, dictate production rhythms, forcing the rest of the industry to adapt. This makes competition more difficult and particularly limits the entry of new third-party ideas into the market, as major innovations must necessarily pass through the larger players, who have the funds and contacts to push them forward, making it extremely challenging for an SME to properly use the typical advantages of GVC.

4. The chip production phases.

After an initial description of GVCs and critical issues in the semiconductor market, let's try to understand how chips are technically produced so that we can better understand how the production chain works.

Chip production consists of three main stages: design, manufacturing, and assembly. Each of these phases requires specialized skills, advanced technologies and the use of high-precision industrial equipment (European Parliament,2022). In the following, I will analyze each of these stages and the companies involved in them in detail.

4.1 Design phase

The design phase is the starting point of semiconductor production and concerns the project of the chip architecture. In this phase, electronic engineers develop complex integrated circuits that must be translated into physical specifications that can later be implemented during manufacturing. Chip design involves three main steps:

- Chip architecture: Here, the structure and operation of the chip is defined, including the selection of materials and components.
- Verification and simulation: Once the chip is designed, simulations are carried out to test the correct functioning of the circuit and verify that there are no errors in the design logic (SAIS Review, 2023)
- Logical and physical synthesis: The logical architecture is transformed into a physical design that can be produced through manufacturing processes. (ASML, 2023)

Companies that focus on the design phase include big names such as ARM Holdings (Arm Ltd), which develops architectures for microprocessors used by many other companies, and Synopsys and Cadence Design Systems, which provide Electronic Design Automation (EDA) software used for semiconductor design and simulation. An example of a company that does both design and manufacturing is NVIDIA, famous for its graphics processing units (GPUs) used in gaming, graphics and artificial intelligence. NVIDIA does not produce the chips in-house but relies on third-party manufacturers for the manufacturing phase.

4.2 Manufacturing Phase

Manufacturing is the most critical and complex phase of semiconductor production, as it requires advanced and highly specialized facilities called foundries. In this phase, the designs developed during the design phase are physically manufactured on silicon wafers. The basic manufacturing steps include (MIRAI, 2024):

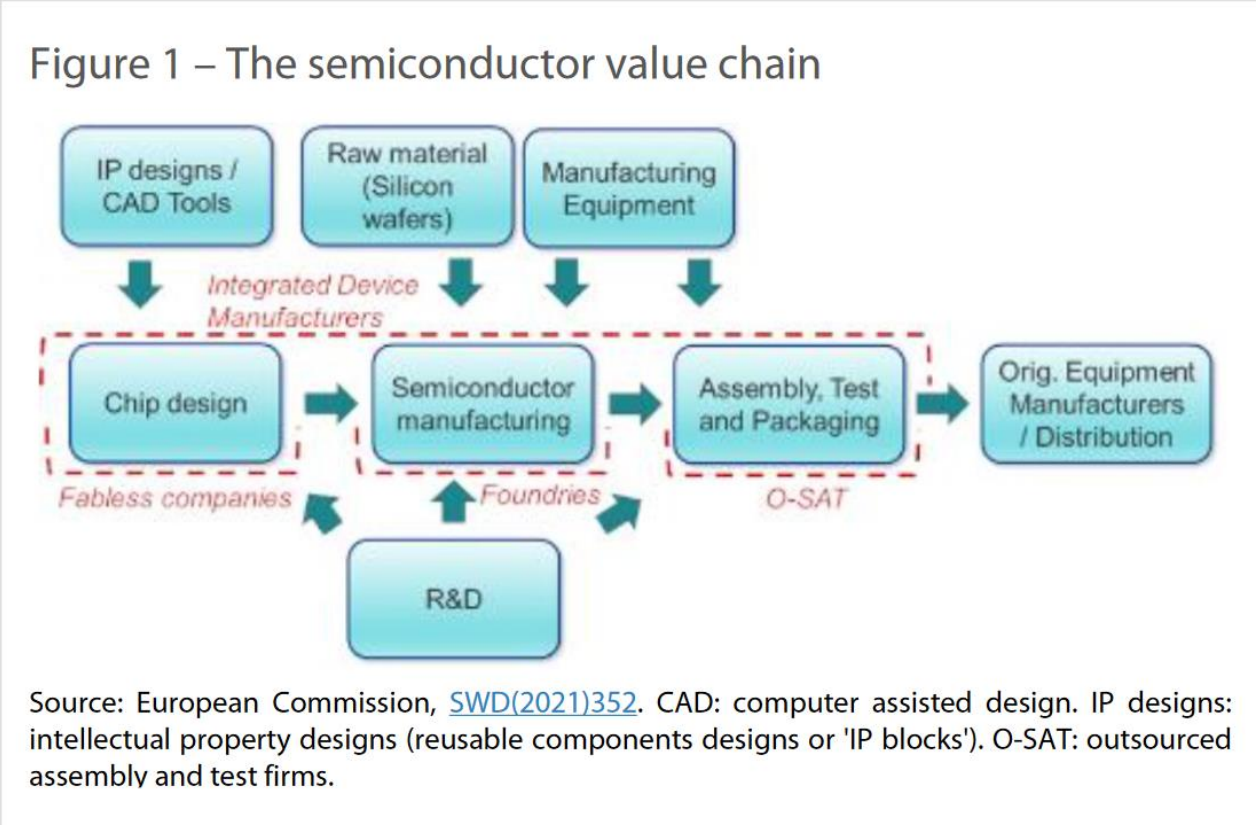
- Deposition: The process of applying thin layers of semiconductor, conducting or insulating materials onto the silicon wafer.
- Lithography: One of the most complex steps, where a pattern is transferred onto the wafer surface using ultraviolet light to define circuits. Advanced technologies such as Extreme Ultraviolet Lithography (EUV) are used to create smaller and smaller circuits.
- Etching: In this stage, parts of the wafer that are not part of the chip design are removed, allowing the circuit to take shape.
- Ion Implantation (or doping): Atoms are bombarded into the wafer to change its electrical properties.
- Chemical Mechanical Planarization: Process that evens out the surface of the wafer, preparing it for subsequent manufacturing steps.

4.3 Assembly Phase (Packaging) and Testing

The assembly phase, or packaging, is the last step in semiconductor production and consists of protecting the chip's circuits within a casing (package) that allows the chip to be connected to the outside world. This step is crucial to ensure the reliability and functionality of the chip in the long term.

- Dicing: Wafers are cut into individual chips, called dies. (ASML, 2023)
- Bonding: The die is mounted on a substrate and electrically connected via metal wires or direct connections (flip-chip bonding). (ASML, 2023)
- Encapsulation: The chip is encapsulated in a protective casing made of plastic or ceramic.
- Testing: Each chip is rigorously tested for correct functioning. Testing includes checking electrical and mechanical parameters, including speed, power and physical integrity. (SAIS Review, 2023)

Packaging plays an essential role, as it directly influences the heat dissipation, performance and durability of the chip. Specialized packaging companies, such as ASE Group and Amkor Technology, dominate this phase. (McKinsey, 2022), picture 6 shows graphically the 3 main chip production stages within the value chain's production steps, demonstrating how each stage in this sector is profoundly influenced by research and development (R&D). Indeed, each of the three phases can generate significant added value if supported by substantial investments in R&D.



Picture 6 (European Parliament, 2022)

5. The three manufacturing approaches

The production chain of chips is indeed articulated and requires many steps, this has led firms in the industry to organize themselves as efficiently as possible to reduce costs and improve production efficiency. Over the years, three main methods of chip production have emerged: the integrated device manufacturer (IDM), fabless, and foundry models. Each of these models presents a different approach to manufacturing with a different level of control over design and distribution. Each of these models, however, offers specific advantages and disadvantages:

5.1 Fabless

Fabless companies, such as Qualcomm and NVIDIA, design the chips but outsource production to specialized foundries such as TSMC or GlobalFoundries (News, TrendForce Insights"). This model reduces capital costs, allowing fabless companies to focus exclusively on innovation and design. This has allowed Nvidia to be an extremely lean company that has grown dramatically over the past four quarters, taking advantage of its partnerships with TSMC. Now, NVIDIA has 'only' around 29,000 employees with a revenue of over $100 billion. Allowing it to have an employee/revenue of 3.69 million (NVIDIA Corporation Stock Analisys, 2024), for comparison, Intel, which instead takes care of all production stages, has a rate of $441.675. However, dependence on foundries can cause capacity problems, especially in times of high demand such as the COVID crisis, which brought problems to NVIDIA.

5.2 Integrated Device Manufacturer (IDM)

IDM companies, such as Intel and Samsung, handle all stages of production (Kumar Priyadarshi, 2023): from design to manufacturing and assembly. This model allows greater control over quality and the production line but requires huge investments to build and maintain state-of-the-art factories. High costs are a significant obstacle, but total control over the entire supply chain ensures efficiency and adaptability in responding to market needs. For example, during the chip crisis Samsung benefited from its vertical integration by not having to rely on orders from an external company such as NVIDA and AMD. These advantages led to a reassessment of the best approach, whereas in the past a fabless foundry approach seemed to bring more profit (Hung et al., 2017). The covid crisis rewarded companies that based their business on foundry construction and chip production (Kreps, 2021)

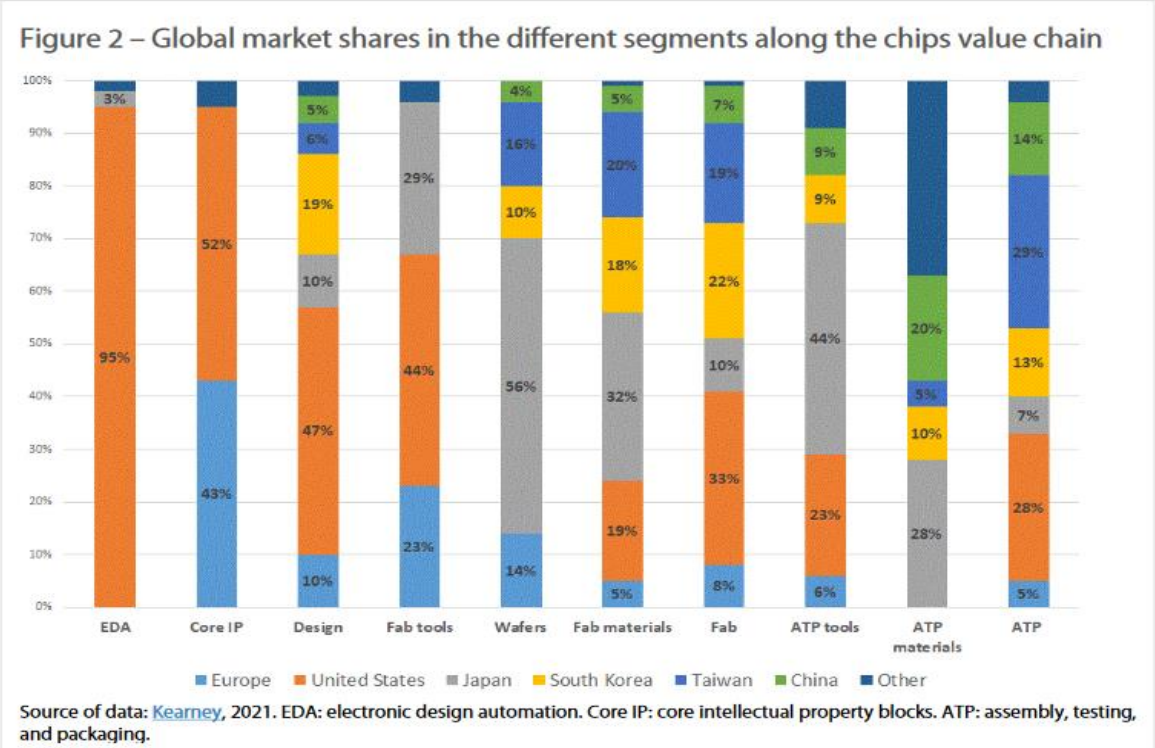
5.3 Foundry

Foundries, such as TSMC and GlobalFoundries, focus exclusively on the production of semiconductors on behalf of fabless companies. Foundries are crucial for the global market, as they provide access to advanced production technologies without the need for fabless companies to invest in factories. The recent high demand for chips has spurred orders to these companies, but they need to always maintain a high production capacity to maximize efficiency and reduce costs.

In the industry, these models coexist and often complement each other; companies such as Samsung for instance operate as both an IDM and a foundry, producing its own semiconductors and offering manufacturing services to third parties (Samsung, 2024). The collaboration between fabless and foundry companies is called the fabless-foundry model and seemed to be particularly fruitful in the past (Hung et al., 2017), but the recent COVID chip crisis has highlighted the more critical aspects of this approach and the need for more manufacturing companies to ensure the resilience of the supply chain.

6. The public intervention: European and Italian chip act:

The European Chips Act, enacted in 2023 (European Commission, 2022), is a regulation designed to enhance Europe's competitiveness and resilience in semiconductor technologies. The Act aims to position the EU as a global technological leader, recovering the production role of the continent in this sector and supporting the digital and green transitions of the European economy. The geopolitical context and rising demand for semiconductors necessitated a robust strategy to address supply shortages and stimulate innovation and production within the EU (European Commission,2022).



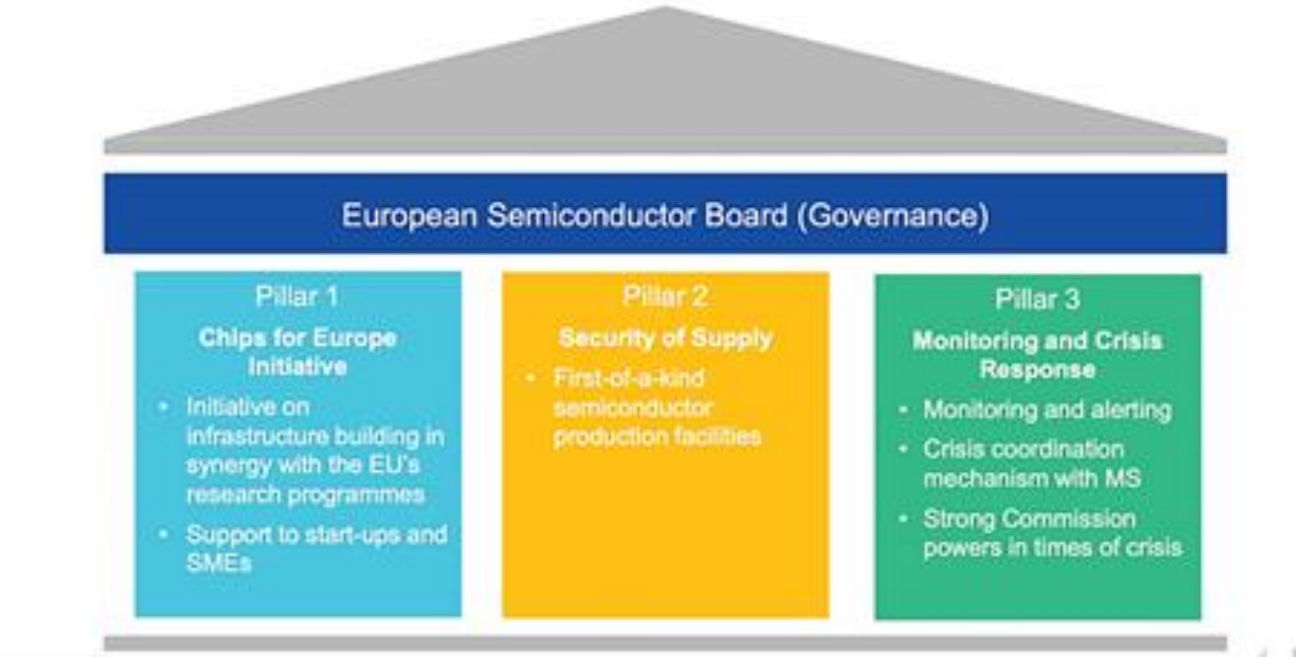
Picture 7 Semiconductor global share (European Parliament, 2022)

The picture 7 shows the global market shares in in each step of the value chain in 2021, as it can be seen Europe is struggling to keep a position in every step and it produces only 8% of the fabs. The European semiconductor production is concentrated in Germany, Italy, Austria, Belgium and Netherlands. (European Commission,2022).

The primary EU commission claim for the Chips Act is to double the EU's global market share in semiconductor production from 10% to 20% by 2030. Achieving this goal requires not only expanding production capacities but also a strong commitment to innovation and the training of a skilled workforce, the final goal is to reduce Europe's dependence on Asian semiconductor imports, promoting technological sovereignty. The creation of new factories and research centers in Europe, such as Intel's "mega" factory in Magdeburg, Germany, represents a significant step towards this goal (MCLellan, 2023). To achieve these results the Eu has allocated an investment 43 billion of euros from public and private funds. (European Commission,2022)

6.1 Practical Implementation of the Chips Act

The European Chips Act is based on three core pillars. Each pillar aims to address specific aspects of the semiconductor ecosystem, with the final goal of giving back to Europe its technological leadership.



Picture 8 (European Commission, 2022)

The first pillar is represented by the Chips for Europe Initiative which aims to improve the innovativeness of the continent in the semiconductor field. The project involves the building of new production lines dedicated to the development of advanced semiconductor chips, the most underdeveloped sector of European industry. Furthermore, a network of competence centers should be established to provide necessary technical training and skill development. Significant funding for research and development projects will be sourced from prominent EU programs like Horizon Europe and the Digital Europe Program. (EU Funding & Tenders, n.d.) This program is expected to improve Europe's capabilities in semiconductor design, production, and testing, resulting in a more self-sufficient and innovative semiconductor sector inside the EU. (European Commission,2022)

The second pillar is dedicated to Security of Supply and Resilience. It aims to secure and enhance the resilience of the EU's semiconductor supply; the final goal is to be less dependent on the far east imports. This system will encourage the construction of new semiconductor production facilities through significant financial incentives and simplified permission processes. Furthermore, it will help to develop new foundries using contemporary production technology. According to the EU commission, creating a supportive regulatory environment will be the key to attracting investments from both European and international semiconductor companies.

The third pillar involves a Coordination and Crisis Response Mechanism to anticipate and rapidly respond to semiconductor supply chain disruptions such as the covid crisis. The establishment of a European Semiconductor Board will coordinate actions between the European Commission, Member States, and industry stakeholders. A comprehensive monitoring system will track semiconductor supply and demand dynamics, while contingency plans and response strategies will be developed to mitigate the impact of supply chain crises. (European Commission,2022)

The European chip act represents the European union's first real response to the years of relentless offshoring in the semiconductor chain and could have very significant consequences for the global semiconductor industry. However, these are long-term investments on which the eventual success can be judged only in many years, Italy will also benefit from the investments and the next chapter will therefore be devoted to studying the state of the country's semiconductor industry.

CHAPTER 3: THE ITALIAN MARKET OF SEMICONDUCTOR

1. The Italian panorama

After the analysis of the chip production, and the current European project in development, I will inspect the Italian market more closely by looking at the firms which operate in it and by evaluating its strengths and weaknesses.

Although the Italian semiconductor market is not particularly developed on a global level, if observed from a European perspective, it has some strengths and great potential for future development. First, it has the presence of a giant in the sector: the Franco-Italian company ST Microelectronics (STM), Europe's leading manufacturer by revenue. Furthermore, Italian expertise is particularly developed in machinery used for various production stages, especially in the clean rooms that are used to make chips and for testing equipment (Ministry of Economy and Finance, 2023).

Like other European companies, Italian companies generally develop chips for specific user sectors such as automotive or sensors for consumer or industrial electronics (Ministry of Economy and Finance, 2023). What is completely lacking, however, as in the rest of Europe, is the development of the most advanced production nodes. Furthermore, a weakness of the Italian system is the absence of large research centers for the development and design of advanced microprocessors; this is a point on which new developments are needed to keep up with the modern market (Ministry of Economy and Finance, 2023). This issue turns out to be central to chip production: to catch up with the giants in the sector, it is necessary to start with research, which, especially in this sector, is indispensable. In this regard, the Chips.it foundation has recently been established, which the government has described as fundamental to the new microelectronics strategy (Dell'Aguzzo,2023). The stated goal of this foundation is to coordinate research activities and to train skills in the sector by functioning as a competence center. To enhance its efficiency the government has sought to create a district in the Pavia area with large companies in the sector having headquarters there (Dell'Aguzzo,2023).

Additionally, to stimulate the country's development in the sector, further investments in the manufacturing will be necessary; the largest limitation of the country is that most

companies are fabless and do not produce directly in the country, in this sense possible future EU investments could be crucial. The only companies that produce semiconductors in the territory are STM (mainly for automotive), and the subsidiaries of foreign companies MEMC (GlobalWafers, USA), Vishay (USA), LFountry (China) and Tower of semiconductor (Israel) The Italian companies, except for the French-Italian STM, are therefore all fabless.

2. The Italian firms

At the top of the Italian market there is the already mentioned STMicroelectronics, which dominates both in terms of revenue and technological innovation. STMicroelectronics is among the largest semiconductor manufacturers globally and is distinguished by a wide range of products, from microcontrollers to sensors and actuators for sectors ranging from consumer electronics to automotive, energy and industrial applications. With production facilities in Italy and a strong focus on R&D, the company is a pillar of the European semiconductor industry (Ministry of Economy and Finance, 2023).

It is followed by medium-sized companies like SECO S.p.A., which specializes in specific vertical markets such as the Internet of Things (IoT) and embedded systems. SECO develops advanced hardware and software solutions for IoT applications, contributing to the development of connected devices and embedded systems for sectors such as healthcare, industrial automation and smart cities. SECO is known for its ability to integrate artificial intelligence technologies into its products, bringing innovation to increasingly important markets (Ministry of Economy and Finance, 2023).

There are also many small companies operating in niche sectors, contributing to innovation through research and development in advanced technologies such as photonics and sensors. For example, LPE is an Italian company specializing in the production of machinery for the epitaxial growth of silicon and silicon carbide, fundamental materials for the semiconductor industry (LPE, 2024). Techno Probe, on the other hand, is a leading manufacturer of probe cards, crucial components for semiconductor testing. OPTOI stands out for the development of advanced sensors based on optical technology, with applications ranging from industrial automation to environmental sensors (Ministry of Economy and Finance, 2023).

Other Italian companies, such as SPEA and OSAI, have also established themselves as leaders in highly specialized sectors. SPEA is one of the world's leading manufacturers of automated testing equipment for semiconductors, microelectronics and MEMS. Its technology is used by global manufacturers to ensure the quality of electronic devices. OSAI, on the other hand, specializes in the production of industrial automation systems and assembly and testing solutions for electronic and semiconductor components. Thanks to its expertise in innovation and robotics, OSAI has acquired a prominent position in the European market (Ministry of Economy and Finance, 2023).

Microtest is another Italian company of international relevance that develops testing solutions for semiconductors and microelectronics. Their expertise lies in the automation of testing processes and the production of sophisticated equipment to ensure high quality standards in semiconductors (Microtest, 2024).

3. Clean rooms in Italy

While the Italian market does not impress for its competitiveness in semiconductors, the clean room sector plays a crucial role in the semiconductor industry and other high-tech sectors. Several Italian companies have specialized in the design and construction of high-quality clean rooms, which are essential to guarantee a controlled and contamination-free environment where the lithography and etching phases of silicon take place. Clean rooms are therefore essential to produce sophisticated electronic components.

One notable example is Meridionale Impianti, a leader in the design and implementation of clean rooms for various industries, including pharmaceutical, biomedical, and semiconductor. Thanks to its expertise in integrating advanced technologies, Meridionale Impianti can provide complete and customized solutions to meet the precision and control requirements of modern clean rooms (Meridionale Impianti, 2024).

Clean rooms are critical environments for the semiconductor industry, as they allow the production of components under conditions of extreme purity and atmospheric control, minimizing the presence of particles that could compromise production processes. Other Italian companies operating in this sector include Camfil Italia, which specializes in advanced filtration solutions, and Delta Impianti, which designs and manufactures ventilation and filtration systems for high-precision environments (Camfil Italia, 2024; Delta Impianti, 2024).

4. Foreign companies

In addition to Italian companies, there are many international manufacturers operating in Italy that have decided during years to invest in the country. Among them, China's LFoundry is a company with great potential but currently at the center of some controversy. Despite its technological capabilities, the management by Chinese ownership (the Chinese company SMIC) has raised doubts about the company's ability to effectively exploit its resources, due to the disengagement strategy that seems to undermine the firm’s competitiveness in the global semiconductor market (Electronics and Markets, 2024). However, in addition to LFoundry, the American Global Wafers has a presence in the territory through its subsidiary MEMC (MEMC, 2024)., which produces the silicon wafers on which Applied Materials chips are then built. Tower Semiconductor also plays an important role in this industrial context.

Furthermore, the European chip act is planning to attract new firms and recent investment have been planned in Italy as the SiliconBox’s 3,2 billion of euros are planned to be spent a 400 million have been financed by EU (Matteo Runchi, 2024) to build an implant in Catania, these foreign investments, together with the chips.it projects, aided by the European chips act, could bring the Italian chips industry back to a good level, but the road is long and a long-term project is needed to resume a production that no longer belongs to the West of the world.

CHAPTER 4: RESEARCH STUDY

1. Italian SMEs

As observed, the semiconductor market is dominated both globally and nationally by large players. To answer the research question of this study and understand the role of Italian SMEs in this setting, I decided to conduct empirical research, directly contacting the companies involved to have a picture as complete as possible of their actual situation and to be able to give a comprehensive answer to the research question. Therefore, in this chapter I will outline all the stages of the study, analyzing the answers given until the elaboration of a final answer.

2. The sample selection:

To gather high-quality data, I opted for a qualitative approach, using semi-structured interviews aimed at understanding which aspects these companies pay the most attention to. The reviews have been structured following three main pillars: The role companies play in chip production and how they work within the market, the barriers they face and final suggestions and opinions for SMEs and public policies.

The sample contacted consisted exclusively of Italian SMEs (with Italian property), understood as companies with less than 250 employees and a revenue of less than 50 million. Even firms who were not SMEs at the time of the interview were included in the sample if they were previously SMEs in the years before.

The sample, although small, was chosen to be quite diverse and to describe the state of Italian semiconductor SMEs as accurately as possible. The interviewed companies work in different steps of the production chain. Most of them are fabless or produce machinery that is part of the semiconductor supply chain or are involved in R&D. During the selection, a lot of emphasis was placed on the diversity element, to deliver the best possible description of the state of the industry in the country. Contacting the companies was not easy, as there is no proper classification, and each had to be contacted individually. Initially I referred to industry ‘s articles to have a first selection of the most important companies (Spadoni, 2024), Then I searched in online databases such as the AIDA(Aida) database and the “camera di commercio” database (Registro Imprese), finally some names were given to me directly by the interviewed companies. The result is a picture that reflects the current state

of companies working in the supply chain, where most produce products to support chip production (such as testing machinery or designs) and rarely produce chips directly.

3. Firms interviewed.

The companies selected mainly work in chip design, testing machinery manufacturing and research and development. Among them, GreenPower Solutions and Eggtronic are fabless chip producers, the former is specialized in chips for the mining and automotive industry, while the latter focuses on microcontrollers for power supply and is more involved with consumer electronics. SEICA and Rise Technology focus on the production of testing machinery for the electronics industry, they represent a huge portion of the Italian SMEs in this sector. Reatech, the smallest of the interviewed companies, is involved in the production of electronic boards for civil and industrial uses. Lastly, CanovaTech is a company dedicated to IP R&D.

Beneath there is a summary of the companies with the description of the products and services they provide:

Company	Year Founded	Location	Core Business	Key Products/Services	Market/Industry
GreenPower Solutions	1998	Volpiano (Turin), Italy	Design, manufacture, and testing of high-power semiconductor devices (fabless model)	Diodes, thyristors, modules, customized modular solutions for motor drives, electroplating, and power conditioning	Motor drives, electroplating, power conditioning, steel milling, mining, renewable energy
SEICA S.P.A.	1986	Strambino (Turin), Italy	Advanced equipment for industrial testing and automation in the electronics industry	Testing equipment for automotive, aerospace, telecommunications, consumer electronics, and medical sectors	Electronics, automotive, aerospace, telecommunications, consumer electronics, medical
Reatech	2016	Rieti, Italy	Production of electronic boards for industrial and civil applications	Customized electronic boards for automation systems, energy management, and other industrial applications requiring reliable components	Automation systems, energy management, industrial applications
CanovaTech	2005	Padua, Italy	IP design company focusing on analog, mixed-signal, and digital IC design	Development of standard and custom IP blocks, complete IC design, custom design services	Industrial applications (high temperatures, electromagnetic interference), R&D in the semiconductor industry
Rise Technology S.r.l.	2006	Rome (Headquarters) & San Martino di Lupari (Manufacturing)	Semiconductor and microelectronics testing, with a focus on deposition and etching processes	Semiconductor testing machinery, photovoltaic sector, microelectronics, patented technologies for deposition and etching processes	Photovoltaics, microelectronics, semiconductor testing machinery
Eggtronic	2012	Modena, Italy	Semiconductor design company focusing on research and development, fabless production model	Microcontrollers, ASICs, power conversion devices, wireless charging systems	Consumer electronics, automotive, industrial

Sources: (RiseTechnology Srl, 2023), (Eggtronic,2020) (SEICA S.p.A., 2024) (Green Power Solutions, 2018) (Canova Tech, 2024) (Reatech, 2015)

4. Interview modality and text.

The interviews were conducted by telephone or web call to accommodate the companies' schedules, the average duration of the interviews was 45 minutes. These were semi-structured interviews in which the interviewee could freely answer questions, sometimes companies asked the full text of the interview in advance to better understand which figure of the company could fit the most. Not all the interviews proceeded in the same way due to the different timeframes given in each interview, but they all provided sufficient information.

The interview was structured in 5 Sections, each concerning a different topic of the research. The first section is introductive and asks the firms their roles and activities in the semiconductor value chain. The second section relates to the entry and innovation barriers, while the third section is about the internationalization barriers and the supply chain management issues of the SMEs. Successively in section 4 the firms are asked about the role of partnership and R&D in their activities. Finally, the last section concerns the companies' perspectives about the Italian semiconductor market, about the European chip act and their reflection and advice for this market.

5. Section analysis

After describing the companies analyzed I am now continuing with the analysis of each section of the interviews, proceeding section by section and interpreting the data from the responses provided. Trying to identify common patterns and differences in the interviews to identify an answer to my research question.

Section 1: Relationship with GVC

The interviewed companies operate in different sectors within the supply chain. Even if they work in the same field, the sample is quite diverse, including companies involved in semiconductor testing machinery such as SEICA and Rise Technology, design, and R&D such as CanovaTech and Eggtronic, or semiconductor design for industrial purposes such as GreenPower Solutions. Finally, Reatech directly manufactures electronic boards in the territory. Thus, a diverse specialization emerges, with each company focusing on different stages of production.

What these companies have in common is that most of them do not produce chips directly in Italy but are almost all fabless; the only exceptions are Reatech's electronic boards and

SEICA and Rise Technology's testing machines. This confirms the limited development of microchip production observed during the market study.

Regarding relationships with the global value chain, most of the companies in the sample have as their first partner other countries, mainly other European countries (Eggtronic, Greenpower solutions) or the United States (CanovaTerch). The access to foreign customers that the value chain offers is an advantage for many companies in the sample, this is confirmed by many of the interviews, in which it is stated that the main customers are often not in Italy. In the case of GreenPower Solutions, the only customers are from outside the country since the firm opted to discontinue relationships in Italy, focusing solely on its overseas customers with whom it feels it performs better. The only exception from the pool is Reatech, which operates solely in Italy and finds extremely difficult to access overseas markets.

Almost all companies affirm that their suppliers come mainly from the Far East (China and Taiwan) for materials, Reatech explains in the interview that today the supply chain starts solely from these countries and no other suppliers can be identified. Companies have therefore integrated into the supply chain by importing resources, as in the case of Reatech, or by producing directly abroad. Eggtronic, Canovatech, and Rise technology, for example, operate in an international context, collaborating with the most important global producers of silicon wafers, with production outsourced to intermediaries abroad, mainly in Taiwan. Even though manufacturing is entirely outsourced, the companies affirm that they must find ways to monitor production efficiently, this has been highlighted during the interview with Eggtronic and GreenPower Solutions. This underlines the importance of having efficient operational practices to effectively exploit the advantages of the GVCs. other companies such as Rise Technology has used its patented technologies as leverage to integrate into the market, and once in, all companies advocate the importance of partnering with various manufacturers or systems integrators to grow in the industry and not fall behind.

Section 2: Entry and Innovation Barriers

The interviews confirm what has been observed in the theory: the barriers to entry into the industry are very significant, mainly concerning access to start-up capital and the lack of specialized skills. Often these barriers have forced companies to specialize in a smaller size as a fabless company. This is the case of Greenpower Solutions, which at the founding of the company in 1996 planned to produce its chip directly, but then due to high costs and international crisis (such as the ENRON scandal) had to abandon the project in favor of a more sustainable fabless company. Eggtronic also confirms that producing this type of product in Italy is very difficult, and they have no plans to do so, as it is too expensive.

Thus, the common challenge for all companies is confirmed to be the raising of the initial capital to start the business. As noted in the study phase, this sector requires very high investment in machinery, and raising capital without resorting to debt is extremely difficult. Most companies, therefore, affirm that in the initial phases, they needed traditional bank financing to overcome this first barrier, while others adopted different strategies. Some, like Rise Technology, benefited from “regional, national, and European” public funds. Others, like Greenpower Solutions, chose to rely solely on their resources without taking out loans or engaging in risky investments, aiming for a more 'resilient' approach to ensure greater stability and reduce dependency on market fluctuations. Finally, Eggtronic states that it relied on external, non-banking entities to finance itself and manage its cash flow until its financial stability.

Another common initial difficulty lies in the mistrust from customers and investors during the first years of operation. All the companies addressed the initial skepticism towards new projects since most companies in the industry “fail within the first five years of operation”. This has made industry firms cautious, as they need suppliers and partners who are reliable both in product quality and supply consistency; The interviewed firms affirm that that to become a supplier of the primary chip makers, steadiness is frequently the most significant component, sometimes more necessary than having a superior product or technology.

This can be explained by the high level of specialization of the market, which requires specific components that only a few companies can produce. Consequently, it is easy for long-term ties to be established and maintained, as global producers will continue relying on the same small suppliers that are able to produce the specific component they need. Thus, maintaining a high supply consistency is crucial for small producers that must

constantly provide the right number of products to the GVC. GreenPower Solutions, for example, states that keeping production active is their primary concern, even during major crises such as COVID-19, as this is what allows the company to remain operational over time.

The problem of establishing these partnerships was highlighted as the most challenging by all companies, who stated that the primary goal in the early years was to “make a name for themselves” by getting known for the quality or innovation of their products and gradually attracting better customers. Some companies suggest that during the first phases, having external consultants to build a network of reliable suppliers could be helpful in overcoming the market’s access difficulties, others, such as Reatech or GreenPower Solutions counted solely on their product, firmly believing that its quality would have convinced the market, repaying their investments.

Finally, the most important barrier in the industry is the lack of specialized skills, this has also been a theme reported by all the interviews, all the companies stressed the impossibility of finding specialized figures in microelectronics underlining a strong gap in the Italian labor market. Hiring new employees is extremely difficult in the early stages, which is why most of the companies in the sample were founded by former employees of larger companies such as, for example, STM (case of CanovaTech).

The difficulty in obtaining specialized personnel remains even afterward, all the companies emphasized how impossible it is to find the required skills in the Italian labor market and how it is a problem for the whole industry. The average response to this issue was to continue to train personnel by hiring recent graduates or collaborating with universities: SEICA, for example, collaborates with the polytechnic of Turin by hiring young people of different nationalities. However, as pointed out during the interview with Rise Technology, the training process is likely to be very long due to the specific skills needed. Investment in young people still involves high risk and delayed return. Retaining these employees is yet another complex challenge, since SMEs may not always offer the opportunities and salaries of multinationals in the industry. An interesting approach mentioned during the interviews is a two-way strategy: on the one hand, the small firm tries to hire experienced leaders (although this is very costly) on the other hand it hires young recent graduates whom it trains during the dissertation process, this allows to cut the training costs and reduce the risk of investments on young employees.

An interesting insight in this aspect comes from CanovaTech, which confirms the difficulty of hiring, though it affirms that it is more difficult to hire than to retain employees, since once involved in projects, employees tend to stay for a relatively long time, however, this is probably a characteristic of the R&D background of the company, since other more production-oriented companies like Reatech say it is difficult to keep workers with them.

Section 3: Internationalization problems

Regarding international barriers and problems in internationalizing business, many companies confirmed that they have experienced problems caused by international turmoil, for example, GreenPower Solutions lost a supplier following the Russian invasion of Ukraine, while CanovaTech has many partners stuck in Israel following the outbreak of the conflict, as well as problems in collaborating with China caused by the U.S. China-ban. From this point of view, diversification of customers turns out to be very useful to be more solid: Rise technology lost its Russian supplier, but it was just 1 out of 4 suppliers. However, this is an industry where very long-lasting collaborations are established and losing a historical partner is likely to be disruptive. In addition, the supply chain is heavily dependent on imports from the east, and in the case of import downturns, difficulties are inevitable. Reatech and Eggtronic for example reported difficulties following the recent problems in the Suez Canal that have blocked many imports. Mitigating these risks is extremely difficult for the interviewed companies, who report struggling with international market fluctuations. To address this issue, some firms affirm to have relied on close relationships with shipping companies, seeking preboarding and discounts, confirming how important logistics strategies are for SMEs operating on a global scale.

Not all companies said they have suffered directly from international crises, but all are suffering or benefiting from the semiconductor market trends, which, as the interview with Rise Technology explains, is a market with cyclical trends in which sales volumes of large companies rise and fall, consequently affecting the entire supply chain. To deal with this issue, one of the most common strategies is diversification, which takes the form of business diversification or geographic diversification. For example, Rise technology is specialized in both photovoltaics and microelectronics, allowing it not to be solely dependent on one sector. Geographic diversification is another form of risk mitigation, SEICA for example has adopted a capillary structure with subsidiaries in different markets that allow it to have a more stable presence in all its target markets, having branches that

operate in different regions allows the company to compensate for shrinking demand in one region by expanding sales in other areas where economic conditions are more favorable. However, this is a structure the company has achieved after years of investment and a business that has now been going on for more than 38 years.

A different approach has been proposed by GreenPower Solutions, which bases its business on operational resilience and financial prudence the company has renounced sources of bank financing, considered “dangerous”, relying solely on its resources to be less dependent on trends in financial markets and international turbulences.

Finally, International problems are not only about regulations and 'industry trends but also about supplies and supply chain management: specific products are needed on which, as noted in the analysis, large multinational companies often arrive first, since the suppliers of the goods are often in common. This element was confirmed in the interviews, where it was stated that indeed Italian SMEs are in a delicate position within the supply chain, as they must compete with large companies that have much greater bargaining power. Large companies tend to dominate the supply chain, both in terms of prioritizing supplies and negotiating favorable terms, leaving SMEs at a disadvantage. For example, SEICA pointed out that during the pandemic, large players in the industry had priority in supply, while Rise Technology states that this priority condition of large companies is the norm in the market and that during the crisis it only gets worse.

The chip crisis caused by COVID-19 was an important test case in this regard. Not all companies suffered equally, for example, CanovaTech, dealing with R&D, had no problems with orders and inventory management. Affected SMEs have adopted different strategies to deal with supply difficulties during periods of scarcity: the approach of Greenpower Solutions has been to stockpile key materials and components during periods of abundance, to ensure business continuity even when markets are in trouble. This cautious inventory management strategy allows SMEs to reduce dependence on suppliers during crises and mitigate the impact of price fluctuations. What the company said is that their focus is to keep production always running. However, this strategy is not suitable for every company Reatech for instance claims to be “too small” to keep a large inventory and they can focus only on the short-period production.

Another effective strategy is to diversify the supplier network; SEICA, for example, has leveraged its global network of subsidiaries to access different markets and expand its

supplier base. This reduces dependence on single suppliers and increases supply chain resilience. In this way, if a supplier is unable to deliver due to geopolitical issues or resource shortages, the company can turn to other sources of supply. Finally, SMEs that have established long-term relationships with suppliers, based on trust and cooperation, have found greater benefits during times of scarcity. These relationships enable SMEs to obtain supplies even when suppliers are under pressure. One strategy in this regard was proposed by de Rise Technology who argued that showing the manufacturer the innovativeness of the product helped them obtain supplies because the manufacturer saw future potential gains in that project, again specialization and innovation turn out to be key for SMEs. The outcomes of this section are quite interesting as they are confirmed by other studies in different manufacturing sectors. For example, the study by Filippetti and D' Ippolito (2016), focuses on collaborations between manufacturing firms and designers and emphasizes the role of trust and cooperation. The study affirms that the companies that establish long-term relationships based on trust and cooperation with external partners (in the study are external designers) can maximize the benefits obtained from innovation. This is because partnerships based on trust allow a deeper exchange of knowledge that facilitates the appropriation of economic benefits derived from design innovations. The role of trust and cooperation is thus confirmed to be crucial also for semiconductor's SMEs.

Section 4: partnership and R&D

Although the type of collaboration and the role they play varies greatly depending on the company's position in the value chain, the topic of partnership appears to be central to all the SMEs interviewed: companies such as Canova Tech and SEICA have built strategic partnerships with some of the largest players in the industry, benefiting not only from the opportunity to provide their own research and development services but also to obtain valuable technological resources and external expertise. Eggtronic also collaborates with major companies in the industry to manufacture their microcontrollers. These collaborations allow SMEs to position themselves as trusted technology partners within GVCs. Canova Tech, which operates in mask design for chip manufacturing, collaborates with some of the largest companies in the semiconductor industry (global top 20). Although they cannot disclose the names of their partners due to non-disclosure

agreements (NDAs), this close relationship allows Canova Tech to access new technologies and influence industry standardization processes. These collaborations with large players in the supply chain increase the company's visibility and prestige by consolidating its position within the GVCs, creating a significant competitive advantage.

The strategy of collaborations is not limited to corporate partnerships, however: Partnerships with universities and research centers are another key strategy for improving the innovative capacity of SMEs. These partnerships give SMEs access to young talent and the opportunity to cut the cost of research that they often could not afford to develop in-house. These types of partnerships not only provide access to skilled human resources but also allow them to be updated with the latest innovations in the field, maintaining long-term competitiveness. SEICA, for example, uses collaborations with the Polytechnic University of Turin to attract young graduates of different nationalities, thus diversifying its team and enriching the company's human capital with soft skills. As mentioned above, this strategy also entails rather high costs, but it remains the 'only solution' that companies have come up with to maintain innovation. An interesting approach comes from Reatech, which collaborates with engineers developing their projects, by doing so the firm reaches a double objective: on one side the company improves its production and keeps up with the new standards, on the other this allows the company to establish a new relationship, reaching new clients and growing their network. This approach is particularly interesting because it allows the company to be on par with the competition without a huge expenditure on R&D.

R&D plays a central role in the growth of these companies, many of them place continuous innovation of their products at the center of their business, although in different ways. CanovaTech, for example, bases its entire business on research and makes sure that its investments are profitable by following the development of the markets, developing technologies that will become the standard so that it gets there before others on that technology, and then selling the R&D to larger companies that by buying from them will not have to do an internal project. This method, developed to make sure that their R&D is effectively leveraged, is like the one employed by RiseTechnology, which is based on observing market developments before deciding the technology to invest in. Another approach has been proposed by SEICA, which instead just does modular R&D for their products, aimed at offering additional modules to the customer. The modular approach allows them to keep costs low, while at the same time increasing their product lineup.

Finally, in technology-intensive industries such as semiconductors, collaborations with certification and qualification associations are essential to maintain high-quality standards. Rise Technology, for example, works closely with qualification bodies to ensure that their technologies comply with international standards and to guarantee the reliability of their testing systems. This type of partnership ensures that the products and technologies developed meet international standards, enhancing their reputation in GVCs.

Section 5 Future developments and recommendations

When questioned about the possible development of semiconductors in Italy, the companies gave different answers, with some points in common. The general opinions are rather negative: although they believe that the sector will continue to grow, they do not see an adequate entrepreneurial system in Italy, nor sufficient support from public policies. Reatech for example states that the number of suppliers in the sector has halved over the years and they do not see how the trend can be reversed. RiseTechnology believes that the future will be strongly influenced by external factors such as investments by large global companies in relation to government policies adopted. Some companies, such as Rise Technology or SEICA, view the future of the industry with optimism, as they believe that innovation and demand for semiconductor-based technologies will continue to grow. However, GreenPower Solutions stresses that Italy needs to improve its entrepreneurial and manufacturing ecosystem to compete internationally. The lack of a strong entrepreneurial spirit and investment culture, especially in technology start-ups, is a barrier that Italy will have to overcome. Eggtronic also sees the future with optimism, believing that recent investments and policy interests in the sector could bring strong growth. Italy is home to innovative start-ups and a large company in the sector such as STM, which will likely attract a lot of funds, as is happening with SiliconBox investments.

In contrast, companies such as Canova Tech and Greenpower Solutions offer a more cautious perspective. While acknowledging the growth of the industry globally, Canova Tech points out that multinationals are strengthening their oligopoly, making it difficult for SMEs to emerge or grow. Indeed, they assert that the semiconductor industry is heavily dominated by a few large players, constituting a de facto oligopoly and limiting opportunities for SMEs to scale or maintain a relevant position in the long term. GreenPower is very pessimistic about the possibility of the sector developing because of

Italy's underdeveloped entrepreneurial capacity and the tendency to always relocate, even when not very convenient.

All companies agree that it will be necessary for Italian SMEs to specialize in high-tech niche markets to remain competitive. Large companies will “take the lion's role” (RiseTechnology), but SMEs can play a key role as specialized partners in certain stages of the supply chain, GreenPower Solutions states: “We have to specialize in the most complex things because everyone knows how to do the simplest parts, (...) a country is only as big as its manufacturing”.

The first suggestion that emerges very clearly is obviously the specialization, it is impossible to compete with the volumes of larger companies, in particular, Canova Tech stressed that SMEs should focus on technical specialization, offering unique solutions that are difficult to replicate by the big players in the industry. In this way, they can become indispensable partners for multinationals, offering added value at critical stages of production or technological development. For Eggtronic, too, becoming a supplier to large manufacturers is one of the best paths an SME can take, and the company also reiterates the importance of having a network of partnerships and collaborations, coupled with a clear and sustainable growth strategy, taking advantage of its flexibility that larger companies cannot have.

When interviewed regarding the recent European programs (mentioned in the theory), the Italian firms, including Canova Tech and SEICA, express difficulties in accessing European Chip Act funds, mainly due to stringent requirements and complex bureaucratic procedures. Canova Tech pointed out that to access these funds, the firm must meet a very specific set of criteria that few SMEs manage to meet. This makes the whole process not very accessible and useful for smaller realities. This sentiment is also shared by SEICA, which perceives the Chip Act as an initiative that favors large companies, which are more structured and able to navigate through European bureaucracy, rather than SMEs. The feeling is that the funds are available, but that “you have to be lucky” to be able to meet all the necessary conditions to qualify for them, which leads SMEs to feel excluded or marginalized from this initiative, which should instead provide tangible support to the small businesses that make up a significant part of Europe's industrial landscape.

What is more perplexing, however, is not so much the European initiative, but the Italian adaptation to the European directive, which does not seem to be adequate, from the

interviews, particularly the one with CanovaTech, it emerges how Italy is far behind in implementing the European directives in the field with seriousness, in general, the country's actions in this sense have not been taken as a strong commitment but more as a plan to receive funds. From the interview with Rise Technologies emerges the fear that these funds will end up attracting foreign companies to Italy, which, however, will only transfer a secondary part of little value of their production only to brand themselves with a “made in Europe” that is not effective. This would not stimulate at all the development of the production chain but would only allow foreign companies to circumvent any duties.

Despite general skepticism, some companies recognize that the European Chip Act could indirectly benefit SMEs. Greenpower Solutions, Reatech, and Eggtronic, while initially unaware of the details of the initiative, expressed a favorable and optimistic stance, viewing the Chip Act as an opportunity to bring some semiconductor manufacturing back to Europe. The main perceived benefit shared by all the companies is that by increasing manufacturing capacity within the European Union, SMEs could also benefit by becoming strategic suppliers of components or services to the large companies that will receive the funds. For example, Rise Technology stated that they will need to excel at becoming suppliers to these companies, allowing them to grow alongside the receivers of European resources.

Regarding public policy recommendations, various ideas emerged from the companies. Generally, the current initiatives and proclamations do not seem to meet the sector's needs. First, there is no real commitment from the country to adapt to the European directive. Further investments in R&D and support for Italian companies that produce domestically are necessary. However, most companies are wary of using public funds (the only exception being Rise Technology). Strong criticism was directed at the country’s bureaucracy, specifically, SEICA criticized the regulatory instability, with changing regulations leading to altered procedures and costs for the company. Regarding potential public investment, an interesting suggestion came from Canova Tech, which proposed creating national competence centers like those in Germany. These centers could serve as coordinators for SMEs, helping small businesses participate in European calls for proposals and obtain funding, acting as intermediaries between SMEs and European institutions. The presence of an institution dedicated to supporting SMEs in the semiconductor sector could help overcome bureaucratic barriers and improve access to funds.

The interviewee from Canova Tech expressed some hope for the new Chips.it project, which, at least in its intentions, is supposed to work as a competence center and guide the country's technological development. According to the interviewee, such development is essential because this is an industry where exponential growth and innovation are extremely challenging. Upgrading in the GVC is not always feasible, and recent cases like Nvidia, for example, are unique and tied to new technologies like AI. However, in the semiconductor sector, which has existed for over 30 years, the idea of a startup suddenly becoming a major player in the industry is unrealistic. Even if such a startup were to emerge, it would likely be quickly acquired by a larger company. If an SME wants to succeed, and if the country wants to grow its industry, the guidance of a competence center would be extremely important. However, doubts remain among all companies regarding the government's administrative capacity in this area.

Final reflections

The interviews gave us an empirical result regarding the condition of Italian SMEs that we can compare with our theoretical framework to answer the research question.

First, it is worth noting how both the advantages and the difficulties observed in the theory were confirmed by the interviews in the empirical part: Barriers to entry, innovation, internationalization, and supply management are all confirmed by SMEs, the semiconductor market is reconfirmed to be a market with high costs and barriers, which are difficult for smaller companies to sustain. At the same time, the benefits of being part of an international supply chain are reconfirmed: all the companies surveyed source their supplies completely abroad and collaborate mainly with foreign partners, managing to benefit from the value chain despite not having a particularly developed domestic market.

Starting from these confirmations, we can give an answer to the research question. Observing the data obtained we can see that it is evident that the main strategy to integrate into the international production network is the specialization: By specializing in a specific product or technology SMEs are able to enter the market and try to become suppliers of larger companies. This confirms what had been observed in some studies of the sector observed in the theoretical part (Bettiol et al, 2022) (Asian Development Bank, 2015).

Moreover, the companies also confirm the key role of industry partnerships, all of them in fact collaborate with other companies and universities for various purposes, often these are

partnerships for strategic purposes, e.g., supply, other times these are research-oriented partnerships that are often vital for SMEs as they allow them to cut down the high research costs of the industry. Research, while being crucial to keep up with the industry and not be overtaken by competitors, is also central to the theme of specialization. Investing in advanced technologies, although very expensive, can lead to the development of technologies that can be exploited in the market. The SMEs interviewed were very sensitive to this issue, specifying that their R&D investments are very much directed at specific technologies that will give them a good competitive advantage or increased product offerings. From this point of view, it seems that the advantage small companies have over global producers is their great flexibility that allows them to identify the short-term market trends and exploit them in their favor. In fact, many interviewed companies affirm that being small, while a disadvantage because of financial constraints, allows them to be very quick in identifying market trends and investing in them. These answers are remarkable since they confirm some of the post-Fordism theories (Amin, 2011), particularly the theory of flexible specialization, which describes an approach to production based on the short-term adaptability of firms. Short-term adaptability can be explained as the ability of firms to respond quickly to changes in demand by using machinery and highly skilled workers. This is what allows these companies to keep pace with technological advances while maintaining a significant competitive advantage.

Perhaps the most stressed aspect added by the interviews relates to the importance of networking, the companies interviewed always emphasized that the hardest thing in the beginning was to survive without a stable network of contacts, gaining the trust of producers is often the hardest part at the beginning, sometimes harder to overcome than costs and skills, building a strong network is what allows the small firms to grow steadily and survive the market instabilities.

Finally, an interesting theme that some companies mentioned was that of financial and managerial resilience: equipping oneself with such resources and materials that would allow the 'company to be more stable and less dependent on the volatility of international markets. This aspect emerged during the interviews with RiseTechnology and SEICA, and it appears to be the result of years of company development and network building. Rather than being an inherent characteristic of companies, resilience seems to be something that SMEs can aspire to only if they manage to build a sufficiently stable network of clients and suppliers. This must be accompanied by a high level of technological specialization, which

makes them relevant in the supply chain, as well as a good level of risk diversification. If these conditions are met, the company can protect itself from market difficulties and develop its products more smoothly.

CONCLUSION

This study aimed to answer the following research question:

"How can Italian SMEs in the chip sector optimize their participation in Global Value Chains to maximize economic and technological benefits, overcoming existing barriers?"

The study, after an initial theoretical digression in which previous studies on value chains and the semiconductor market were analyzed, continued with a second empirical part in which 6 SMEs in the sector were interviewed through semi-structured interviews. The outcomes are consistent with industry research since the businesses that successfully enter the market confirm to be often extremely specialized in a particular technology that they aim to take advantage of to establish themselves as important suppliers to the value chain.

The interviews show that specialization, as supported by literature, is the main answer to the research question. However, other characteristics were found to be key factors for the sustainability of the SMEs. The emerging factors are R&D, partnerships, network, and logistic-financial resilience.

R&D was found to be key in the industry not only to keep products updated but also as an asset in negotiations with suppliers and large companies. These companies, recognizing the potential of advanced technologies, may foresee future benefits and choose to collaborate with smaller firms. The importance of collaboration emerged as a central theme, particularly the strategic alliances with universities and companies. More importantly, the network of relationships and contacts allows SMEs to remain competitive in the industry and capitalize on the benefits of the value chain. The companies interviewed all affirmed the centrality of forming diversified networks in their business, both for selling products and sourcing materials. According to the interviews, this is a market based very much on trust, and having many long-term partners turns out to be the key to success in the short and long-term.

Finally, a theme that was found to be very important during the interviews is the flexibility of the firms: being small allows these companies to adapt quickly to market trends, investing in the most demanded technologies; this result also turns out to be in line with the

industry literature, confirming the flexible specialization theory of the post-Fordist literature (Amin, 2011).

During the interviews, companies were also asked about semiconductor market trends and future developments. The outlook for Italy was generally negative. Several interviews (such as those with CanovaTech and Rise Technology) revealed that the chip market appears to be a production-driven GVC, where large manufacturers set the rules. These manufacturers, often a few dominant players, form an oligopoly. In such a market, the concept of "upgrading" as discussed in theoretical analysis (Humphrey & Schmitz, 2002), is difficult to achieve. Large companies act as gatekeepers, assimilating every new idea by acquiring the rights of the originators with their financial power.

Companies were also asked for public policy suggestions and opinions regarding the recent European chip act. The opinions expressed were quite negative about the Italian 'act, although not all companies were aware of the new investments. As much as the new investments in the sector are appreciated there is a fear that they will not lead to a real development of the supply chain but on the contrary, could lead the country and Europe to sell out even more to foreign companies that have a European headquarters (financed by Europe) could brand themselves with a non-effective “made in EU”, thus avoiding paying any eventual duties.

Among the proposed ideas the most fascinating one comes from CanovaTech, which is in the recent founding of the Chips.it platform the opportunity to create a competence center that could manage companies in the sector, according to the company, focusing on the overall development of research and development in the country could reverse the trend and gradually bring back part of the production to Italy, but without a developed R&D this would not be possible. In this regard, Draghi's recent speech to the European Parliament marks a very clear objective and in line with the research findings: Europe needs to invest in its resources and innovativeness to become competitive again, investing in research and SMEs, taking advantage of their flexibility and adaptability could be a key piece to kickstart the continent.

Research limitations and future developments.

The main contribution of this research is to highlight the importance of relationships between SMEs and global players, as well as the adoption of strategies that can enable these firms to maximize the economic and technological benefits of their participation in GVCs. The interviews provided a detailed picture of the problems and solutions perceived by entrepreneurs, thus enriching the literature on the role of SMEs in GVCs and opening new perspectives of analysis for the semiconductor industry.

As much as I believe the selected sample is valid and representative, it has some limitations that should be considered. The first is due to the difficulty in contacting companies in the sector, an issue that also emerged in the interviews obtained, the sector is not yet mature and it is difficult to be able to contact all the companies, some for example emerged only during the interview with other companies, although the most important exponents were contacted, the study, however, does not consider them all. In addition, the qualitative methodology employed based on semi-structured interviews, although it allows for the collection of very in-depth data, it risks adding elements of subjectivity and personal bias, as the interviewees provided their personal view, which despite being that of workers in the industry is not necessarily an objective data, this could slightly distort the results.

Regarding possible further developments, the research suggests, in my opinion, the need for a further investigation of policy interests in the sector, to understand what aid has been provided and what projects are in place, to understand if and how much the sector can grow in Europe but more importantly where public policy should focus.

Finally, the focus is exclusively on the Italian market, it might be interesting to extend the study to other countries to understand whether certain dynamics are common to other markets, for example, the European market.

Bibliography

Adams, R. D. (2021, March 3). PS5 supply shortage: Disruptions affect gamers and developers alike. *TechRepublic*. https://www.techrepublic.com/article/ps5-shortage-supply-chain-disruptions-affect-gamers-and-developers-alike/

Amin, A. (2011). Post-Fordism (1st ed.). Wiley-Blackwell. https://www.perlego.com/book/1007185 chapter 5

Antràs, P., & Chor, D. (2022). Global value chains. In K. Bagwell & R. W. Staiger (Eds.), *Handbook of International Economics: International Trade* (Vol. 5, pp. 297–376). Elsevier. https://doi.org/10.1016/bs.hesint.2022.02.005

Asian Development Bank. (2015). *Integrating SMEs into global value chains: Challenges and policy actions in Asia*. Asian Development Bank.

Baldwin, R. E. (2016). *The great convergence: Information technology and the new globalization*. Harvard University Press.

Baldwin, R., & Ito, T. (2021). The smile curve: Evolving sources of value added in manufacturing. *Canadian Journal of Economics/Revue canadienne d'économique, 54*(4), 1842–1880. https://doi.org/10.1111/caje.12555

Bettiol, M., Burlina, C., Chiarvesio, M., & Di Maria, E. (2022). SMEs and the regionalization of global value chains: An untold story from the Italian industrial districts. *Competitiveness Review: An International Business Journal*. https://doi.org/10.1108/cr-11-2021-0161

Bettiol, M., Di Maria, E., & Grandinetti, R. (2022). *SMEs in global value chains: The Italian experience*. Routledge.

Berman, B., & Thelen, S. (2018). Planning and implementing an effective digital marketing strategy. *International Journal of Business and Management, 13*(2), 1–12. https://doi.org/10.5539/ijbm.v13n2p1

Congressional Research Service. (2023). Frequently asked questions: CHIPS Act of 2022. https://crsreports.congress.gov/product/pdf/R/R47523

Cornet, A., Heuss, R., Schaufuss, P., & Tschiesner, A. (2023, August 31). A road map for the automotive industry in Europe. *McKinsey & Company*.

https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/a-road-map-for-europes-automotive-industry

Filippetti, A., & D'Ippolito, B. (2016). Appropriability of design innovation across organisational boundaries: exploring collaborative relationships between manufacturing firms and designers in Italy. Industry and Innovation, 24(6), 613–632. https://doi.org/10.1080/13662716.2016.1263888

Fuchs, M. (2022). The coordination and configuration of global value chains (GVCs). In *Global Value Chains: Transformation and Challenges in the 21st Century* (pp. 231–268). Springer. https://doi.org/10.1007/978-3-662-65870-3_6

Gereffi, G., & Korzeniewicz, M. (Eds.). (1994). *Commodity chains and global capitalism*. Praeger.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology, 91*(3), 481–510. https://doi.org/10.1086/228311

Hopkins, T. K., & Wallerstein, I. (1986). Commodity chains in the world-economy prior to 1800. *Review (Fernand Braudel Center)*, 10(1), 157–170.

Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies, 36*(9), 1017–1027. https://doi.org/10.1080/0034340022000022198

Hung, L.-Y., Liao, Y.-T., Huang, W.-C., & Cheng, Y.-C. (2017). Design of a wireless power transfer system with high misalignment tolerance for capsule endoscopy. In 2017 IEEE International Symposium on Circuits and Systems (ISCAS) (pp. 1-4). IEEE. https://doi.org/10.1109/ISCAS.2017.7914779

Inomata, S. (2017). Analytical frameworks for global value chains: An overview. *Global Value Chain Development Report 2017*. World Bank.

Keller, K. L. (2008). *Strategic brand management: Building, measuring, and managing brand equity* (3rd ed.). Pearson Prentice Hall.

Larsen, P., & Lewis, A. (2007). How award-winning SMEs manage the barriers to innovation. *Creativity and Innovation Management, 16*(2), 142–151. https://doi.org/10.1111/j.1467-8691.2007.00428.x

Lee, J., & Grewal, R. (2014). Strategic responses to commoditization in a value chain: The smiling curve and firm boundaries. *Strategic Management Journal, 35*(10), 1479–1496. https://doi.org/10.1002/smj.2177

Madrid-Guijarro, A., Garcia, D., & Van Auken, H. (2009). Barriers to innovation among Spanish manufacturing SMEs. *Journal of Small Business Management, 47*(4), 465–488. https://doi.org/10.1111/j.1540-627X.2009.00279.x

Madrid-Guijarro, A., Garcia, D., & Van Auken, H. (2009). Barriers to innovation among Spanish manufacturing SMEs. Journal of Small Business Management, 47(4), 465–488. https://doi.org/10.1111/j.1540-627X.2009.00279.x

Mallah, S. I., et al. (2021). COVID-19: Breaking down a global health crisis. *Annals of Clinical Microbiology and Antimicrobials, 20*(35).

Miller, C. (2022). *Chip war*. Simon & Schuster.

Ministero dell'Economia e delle Finanze. (2023). Nota tematica n. 3/2023. *Ministero dell'Economia e delle Finanze*. https://www.dt.mef.gov.it/export/sites/sitodt/modules/documenti_it/analisi_progammazione/note_tematiche/Nota-Tematica-n-3-2023.pdf

Mudambi, R. (2008). Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography, 8*(5), 699–725. https://doi.org/10.1093/jeg/lbn024

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

Roy, A., Sekhar, C., & Vyas, V. (2016). Barriers to internationalization: A study of small and medium enterprises in India. *Journal of International Entrepreneurship, 14*(4), 513–538. https://doi.org/10.1007/s10843-016-0187-7

Shih, S. (1996). *Me-Too is not my style: Challenge difficulties, break through bottlenecks, create values*. Acer Foundation.

Sinkovics, N., Sinkovics, R. R., & Archie-Acheampong, J. (2021). Small- and medium-sized enterprises and sustainable development: In the shadows of large lead firms in global value chains. *Journal of International Business Policy, 4*(1), 80–101. https://doi.org/10.1057/s42214-020-00089-z

Sturgeon, T., Van Biesebroeck, J., & Gereffi, G. (2008). Value chains, networks and clusters: Reframing the global automotive industry. *Journal of Economic Geography, 8*(3), 297–321. https://doi.org/10.1093/jeg/lbn007

Sitography

[News] TSMC reportedly sees strong 4nm demand, with NVIDIA's order up by 25%. (2024, July 15). *TrendForce Insights*. https://www.trendforce.com/news/2024/07/15/news-tsmc-reportedly-sees-strong-4nm-demand-with-nvidias-order-up-by-25/

ANI. (n.d.). The European Chips Act. https://www.ani.pt/en/international-promotion/global-network/the-european-chips-act/

Arm Ltd. (2015). Architecting a smarter world – Arm. *Arm | The Architecture for the Digital World*. https://www.arm.com/

Arcuri, G., & Lu, S. (2022, March 22). Taiwan's semiconductor dominance: Implications for cross-strait relations and the prospect of forceful unification. *Center for Strategic and International Studies*. https://www.csis.org/blogs/perspectives-innovation/taiwans-semiconductor-dominance-implications-cross-strait-relations

ASML. (2023). Six crucial steps in semiconductor manufacturing. *ASML*. https://www.asml.com/en

Bartlett, K., Li, L., Vrijen, R., & Wiseman, B. (2023, January 27). Semiconductor fabs: Construction challenges in the United States. *McKinsey & Company*. https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-fabs-construction-challenges-in-the-united-states

Camfil. (n.d.). *Camfil Italia: Soluzioni di filtrazione dell'aria e pulizia dell'aria*. Camfil. https://www.camfil.com/it-it/ (Accesso a luglio 2024).

Chang, S. J., & Grubb, J. W. (2012). The smiling curve: Do you have a strategy for value creation? *Harvard Business Review*. https://hbr.org/2012/08/the-smiling-curve

Chi siamo: il brand di denim più innovativo al mondo. (n.d.). Diesel. https://it.diesel.com/it/about-diesel.html

Cunningham, A. (2023, August 7). Report: Apple buys every 3 nm chip that TSMC can make for next-gen iPhones and Macs. *Ars Technica*.

https://arstechnica.com/gadgets/2023/08/report-apple-is-saving-billions-on-chips-thanks-to-unique-deal-with-tsmc/

Dell'Aguzzo, M. (2023, November 6). Semiconduttori, tutto sulla nuova Fondazione Chips.It di Pavia. *Startmag*. https://www.startmag.it/innovazione/fondazione-chips-it-pavia/

European Commission. (2022). Chips Act Package. https://ec.europa.eu/newsroom/repository/document/2022-13/22020329_Chips_Act_Package__Complete_I7LhdGOvIcf7Qbud9zgZlIPiWrA_85575.pdf

European Commission. (2022). The European Chips Act. *European Commission*. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_it

European Parliamentary Research Service. (2022). The European Chips Act: Strengthening Europe's semiconductor ecosystem (EPRS Briefing No. 733596). *European Parliament*. https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733596/EPRS-Briefing-733596-EU-chips-act-V2-FINAL.pdf

Fei Cui Overbeek. (2023, June 21). The coffee supply chain: How does it work? *Hermanos Colombian Coffee Roasters*. https://hermanoscoffeeroasters.com/blogs/blog/the-coffee-supply-chain-how-does-it-work-1

History and Milestones of TSMC. (2019, May 11). *AnySilicon*. https://anysilicon.com/history-and-milestones-of-tsmc/

Kreps, S. (2021, June 30). A holistic approach to strengthening the semiconductor supply chain. Brookings. https://www.brookings.edu/techstream/a-holistic-approach-to-strengthening-the-semiconductor-supply-chain/

Kumar Priyadarshi. (2023, August 30). Explained: What the hell IDM, fabless, or fab-lite model? *Techovedas*. https://techovedas.com/explained-what-the-hell-idm-fabless-or-fab-lite-model/

Lu, M. (2023, June 12). Ranked: Largest semiconductor foundry companies by revenue. Visual Capitalist. https://www.visualcapitalist.com/semiconductor-foundry-companies-ranked/

Matteo Runchi. (2024, September 8). Intel in crisi annulla gli investimenti: Che fine farà la fabbrica che doveva costruire in Italia. *QuiFinanza*. https://quifinanza.it/innovazione/intel-crisi-fabbrica-chip-italia/849028/

McKinsey & Company. (2022). Semiconductor design and manufacturing: Achieving leading-edge capabilities. *McKinsey & Company*. https://www.mckinsey.com

Mclellan, C. (2023, February 9). Intel wants German cash for Magdeburg mega fab. The Register. https://www.theregister.com/2023/02/09/intel_10b_german_fab/

McLellan, E. (2023, August 4). The European Chips Act: A vital step in the right direction. *Wilson Center*. https://www.wilsoncenter.org/article/european-chips-act-vital-step-right-direction.

Merimp. (n.d.). *Merimp: Il tuo partner per il commercio internazionale*. Merimp. https://www.merimp.com/ (Accesso a luglio 2024).

Microtest. (n.d.). *Microtest: Advanced solutions for electronic testing*. Microtest. https://www.microtest.net/it/ (Accessed in July 2024).

"Photolithography in Chip Making Process." (2024, March 18). *MIRAI Intex Technology*. https://mirai-intex.com/blog/photolithography-in-chip-making-process/

SAIS Review. (2023). Clash of the chips: A comparison of US-China semiconductor production capacities. *SAIS Review of International Affairs*. https://saisreview.sais.jhu.edu

Samsung. (2024). From foundry to fabless: An overview of the semiconductor ecosystem. Samsung Semiconductor. https://semiconductor.samsung.com/news-events/tech-blog/from-foundry-to-fabless-an-overview-of-the-semiconductor-ecosystem/

Seabolt, D. D., Mitch, P., & Jacob, P. (2021, August 3). The chip shortage of 2021: Implications for the global economy. *Blue Chip Partners*. https://www.bluechippartners.com/blog/the-chip-shortage-of-2021-implications-for-the-global-economy/

StockAnalysis. (n.d.). NVIDIA Corporation (NVDA) Stock Analysis & Price. StockAnalysis. Retrieved September 30, 2024, from https://stockanalysis.com/stocks/nvda/

Taiwan Semiconductor Manufacturing Company Limited. (n.d.). *TSMC Arizona*. Retrieved August 26, 2024, from https://www.tsmc.com/static/abouttsmcaz/index.htm

"Registro Imprese | I Dati Ufficiali Della Camera Di Commercio." (n.d.). *RegistroImprese.it*. https://www.registroimprese.it/

"Aida." (2024). *Bvdinfo.com*. https://login.bvdinfo.com/R0/AidaNeo?SetLanguage=it

Company. (2023). Rise Technology Srl. https://risetechnology.com/company

Eggtronic. (2020). Company | Eggtronic - Revolutionary power electronics for a better planet. *Eggtronic*. https://www.eggtronic.com/company/

Flying Probe Testers - Automatic Test Equipment (ATE) - In-circuit Test. (2024, August 26). *Seica Spa*. https://www.seica.com/it/gruppo-seica/

Funding & tenders. (n.d.). *European Commission*. https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/digital

Green Power Solutions. (2018). *Gpsemi.it*. https://gpsemi.it/company

Impresa Delta. (n.d.). *Impresa Delta: Servizi e soluzioni per l'edilizia*. Impresa Delta. http://impresadelta.it/ (Accesso a luglio 2024).

Innovative Semiconductor Solutions | Canova Tech. (2024, June 28). *Canova Tech Srl*. https://www.canovatech.com/company/

Reatech. (2015). *Reatech.net*. https://www.reatech.net/

United Nations Conference on Trade and Development (UNCTAD). (2017). *Integrating SMEs into global value chains can boost development*. UNCTAD. https://unctad.org/news/integrating-smes-value-chains-can-boost-development

World Trade Organization. (2010, November 10). WTO successfully concludes negotiations on China's entry. WTO | News - WTO Successfully Concludes Negotiations on China's Entry -Press 243. Retrieved from https://www.wto.org/english/news_e/pres01_e/pr243_e.htm

Interview Questions:

Section 1: Introduction

Can you briefly describe your company's role in the semiconductor value chain?

What are the main benefits you have experienced from being part of a GVC?

What strategies do you adopt to leverage the advantages of GVCs? Are there specific technologies or practices that have improved your operational efficiency within GVCs?

Section 2: Entry and Innovation Barriers

What were the main challenges you encountered when entering the chip market?

How do you overcome the challenges related to the need for large capital and specific skills?

How difficult is it for you to maintain a steady flow of qualified human capital to support the innovation of the company?

What strategies do you use to stimulate and sustain innovation within your company?

Section 3: Internationalization Issues

Did your company experience problems related to regulatory changes in international markets? If so How do you manage issues like that?

What strategies do you adopt to mitigate risks associated with international economic fluctuations?

How do larger companies in the sector influence your ability to manage the supply chain?

Have you encountered difficulties in securing supplies during periods of resource scarcity? If so, how have you addressed these difficulties?

Section 4: Competitiveness Strategies

What is the role of collaborations and strategic partnerships in your business? Can you provide examples of successful collaborations that have improved your position in GVCs?

How much do you invest in research and development (R&D)?

How do you ensure that these investments lead to a sustainable competitive advantage?

Section 5: Future and Recommendations

What are your predictions for the future of the chip sector in Italy?

How do you think Italian SMEs can strengthen their presence in GVCs in the coming years

What advice would you give to other SMEs that want to enter or improve their position in GVCs?

Are there any government policies or support that you consider essential to facilitate the integration of Italian SMEs into the global chip market?

What do you think about the European chip act? If so, how do you think the funds and support from this initiative can benefit your company?

What specific measures or support from the European Chip Act would be most beneficial for your business?

Interview Information

Company Name	Interviewed figure	Duration of Interview
Rise Technologies	CEO	54 minutes
SEICA	CEO	25 minutes
Eggtronic	CEO	26 minutes
CanovaTech	Business Development Engineer	45 minutes
Reatech	CEO	35 minutes
GreenPower Solutions	CEO	2.40 hours