BACHELOR THESIS MANAGEMENT, SOCIETY & TECHNOLOGY FACULTY OF BEHAVIOURAL, MANAGEMENT AND SOCIAL SCIENCES

OPTIMISING GOVERNANCE:

LEVERAGING THE EU CHIPS ACT TO ENHANCE THE MARKET POSITION OF THE DUTCH SEMICONDUCTOR INDUSTRY

EMMA DE WEGER
S2379414

28/06/2023
WORD COUNT: AROUND 12.000
ETHICAL APPROVAL NUMBER: 230658

1ST SUPERVISOR: DR. P.J. KLOK
2ND READER: DR. I. BOUZGUENDA

UNIVERSITY OF TWENTE.

TABLE OF CONTENTS

ABSTRACT

This study explores the Dutch semiconductor industry's growth potential under the European Union (EU) Chips Act. It will give an answer to the question: "What mode of governance fits best for the Dutch semiconductor industry to use the opportunities provided by the EU Chips Act to improve its market position?" It examines the current strengths and weaknesses of the industry, the existing mode of governance, and the opportunities that the EU Chips Act presents for strategic growth to enhance Europe's autonomy and competitiveness in the semiconductor industry. Based on a comprehensive analysis of the industry's SWOT characteristics and the EU Chips Act's main objectives, it proposes a network governance model, incorporating market and knowledge governance, to effectively leverage the Act's benefits. By embracing strategies like increased collaboration through a triple-helix approach, advocating for the establishment of competence centres and pilot lines, the Dutch semiconductor sector can enhance its global position. The government can further support this by facilitating access to the Chips Joint Undertaking (JU) resources, investing in education, and training, and promoting and supporting the establishment of competence centres and pilot lines. These findings will assist policymakers and the industry in informed decision-making, promoting the Dutch semiconductor industry's growth and its contribution to the economy.

1. INTRODUCTION

These days, chips are used in many applications: almost all hardware contains chips. Think about cars, computers, household appliances, in traffic: traffic lights, train switches, matrix signs, and in passes: bank cards, public transport chip cards, and credit cards. A chip is a set of electronic circuits on a small piece of semiconductor material (usually silicon), also called a wafer. The demand for chips is very high. The European Union (EU) produced over 40 percent of all chips in 1990, which has now dropped to just 10 percent (Van Gerven, 2022).

‘’Semiconductors are at the heart of the geopolitical scene with tensions rising between the US, China, and Taiwan’’ (Ciani & Nardo, 2022; Zhang et al., 2023; Huggins et al., 2022). Where China is focussing on technological self-reliance through semiconductor production, the US and South Korea respond with significant investment plans for domestic semiconductor manufacturing, intending to increase their market share and attract private investment. The US, in particular, has approved a $52 billion investment plan (Ciani & Nardo, 2022; Bown, 2020).

The Covid-19 pandemic brought about unprecedented challenges for the global economy and exposed vulnerabilities in various sectors, including the semiconductor industry. As the demand for electronic devices surged with the rapid shift towards remote work and online activities, the European Union (EU) realized the pressing need to address its reliance on foreign sources for crucial chip technologies (Aurik et al., 2022; Ciani & Nardo, 2022; Huggins et al., 2022; KPMG, 2020; The European Chips Act, n.d.; Zhang et al., 2023; Bish et al., 2022).

Against the backdrop of the Covid pandemic, the global chip shortage, and the geopolitical situation, the EU followed the US example and launched the EU Chips Act to regain a more prominent place in the chip industry. The EU Chips Act embodies a broader, longer-held EU ambition for ‘strategic autonomy’ (Vasquez, 2023). The objective is not to become self-sufficient but to build a strong semiconductor sector and a resilient supply chain capable of anticipating and responding to future disruptions (European Commission, 2023). The EU adopted the European Chips Act to double its semiconductor market share by 2030 from 10% to 20% (Ciani & Nardo, 2022) (Bish et al., 2022). Moreover, the EU Chips act fits well in the context of the EU Digital Compass plans, presented in March 2021. According to these plans, the 2020s should be Europe’s digital decade.

The Dutch semiconductor industry has been a major player in the global market for several decades and is an essential contributor to the economy of the Netherlands. The Netherlands has a highly skilled workforce, a strong research and development infrastructure, and a supportive government that has invested heavily in the industry. As a result, Dutch companies such as ASML, NXP Semiconductors, and Philips have become leaders in the production of chips for a wide range of applications (Statista, 2023). With the rapidly changing technological landscape, the industry must continuously adapt and innovate to maintain its competitive edge.

This research bachelor project addresses the question: "What mode of governance fits best for the Dutch semiconductor industry to use the opportunities provided by the EU Chips Act to improve its market position?”

From my main question, the following sub-questions have been derived:

1. What are the current strengths and weaknesses of the Dutch semiconductor industry?
2. What are the characteristics of the current mode of governance of the Dutch semiconductor industries?
3. What are the European Chips Act's main objectives and policy interventions regarding the semiconductor industry?
4. What opportunities does the European Chips Act provide for the Dutch semiconductor industry to change its mode of governance and improve its market position?

This research aims to identify an approach for the Dutch semiconductor industry to strengthen its global position within the context of the EU Chips Act and for the government to support the industry and, by doing that, strengthen the Dutch economic position and situation. The research will contribute to understanding the impact of government policies and regulations on the semiconductor industry, particularly in Europe. The study will explore the characteristics of the current mode of governance of the Dutch semiconductor industry and how it can be changed to improve its market position through the opportunities provided by the European Chips Act. This research's findings can help policymakers make informed decisions supporting the growth and development of the Dutch semiconductor industry and its contribution to the economy.
The EU Chips Act is new. The findings of this research will add to the existing literature on the semiconductor industry and provide insights into the potential impact of government policies and regulations on industry competitiveness and, more importantly, how the Dutch semiconductor industry can benefit from the EU Chips Act. This research will benefit the Dutch and European semiconductor industry in identifying concrete modes to strengthen its global position, push forward the digital transformation of the European economy, and increase strategic autonomy.

2. BACKGROUND

This chapter introduces the (Dutch) semiconductor industry and its value chain. It discusses various aspects of the semiconductor industry, including the different categories of semiconductors, the well-known Moore's Law, the manufacturing process of semiconductors, the geopolitical tensions surrounding semiconductors, the economic importance, the global supply chain and its susceptibility to disruptions, and the importance of research and development.

2.1 What is a semiconductor?

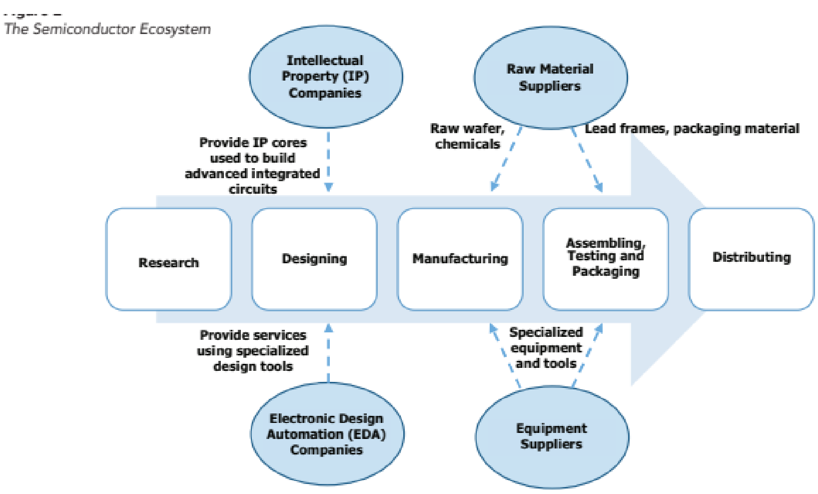
The terms “chip” and “semiconductor” are closely related. A chip is a small electronic device comprising interconnected components, like transistors, resistors, and capacitors, fabricated on a small piece of semiconductor (Huggins et al., 2022; Nathan Associates Inc., 2016; Zhang et al., 2023). All components are interconnected through metallization layers to form a functional circuit. Chips are, therefore, also known as integrated circuits (ICs). Semiconductors are crucial chip components: it is the building block of the chip, in the form of a thin, round slice, also called a wafer (Ciani & Nardo, 2022; Huggins et al., 2022; Nathan Associates Inc., 2016). Silicon (Si) is currently the most commonly used material (Ciani & Nardo, 2022). A semiconductor is the material that exhibits specific electrical properties. While the chip (or integrated circuit) is the physical device made from the semiconductor material that contains multiple interconnected electronic components. However, “semiconductor” is often a synonym for “chip.”

2.2 Semiconductor value chain

The semiconductor value chain has five stages or phases.

Figure 1

The semiconductor ecosystem



Source: Nathan Associates Inc., 2016

The chain starts with Research (and Development (R&D)) and ends with Distributing the chips. R&D drives the industry to make rapid technological advancements. The semiconductor sector is a typical knowledge-intensive sector (Tweede Kamer der Staten-Generaal, 2020; Nathan Associates Inc., 2016;

OECD, 2019; Zhang et al., 2023; Lammertink et al., 2023; Baron, 2023; Kieckens, 2021). Researchers constantly seek to increase semiconductor devices' processing capability and speed while reducing costs, following Moore's Law (see paragraph 2.4) (Nathan Associates Inc., 2016; Huggins et al., 2022; Zhang et al., 2023). Research outcomes are a key input to the design stage, which relies heavily on highly skilled engineers and human capital (Nathan Associates Inc., 2016; Ciani & Nardo, 2022; Lammertink et al., 2023; OECD, 2019; Van Wieringen, 2022). The next phase, the Design phase, requires significant investments and is only possible using highly sophisticated software supplied by electronic and design automation (EDA) software. In the design stage, companies design new chips based on particular and dedicated specifications to meet customer needs (Nathan Associates Inc., 2016; Ciani & Nardo, 2022; Lammertink et al., 2023; OECD, 2019; Van Wieringen, 2022).
The third phase is the actual Manufacturing by foundries in fabs[1]. In this phase, the designed chips are manufactured. The production is highly capital-intensive, and complexity continuously increased over the years and is still increasing due to the explosive technological evolution and demand. Many companies are involved in this phase, such as suppliers of raw materials and semiconductor manufacturing equipment (SME) (Nathan Associates Inc., 2016; Ciani & Nardo, 2022; Lammertink et al., 2023; OECD, 2019; Van Wieringen, 2022). The next stage is the phase of Packaging, Assembling, and Testing. This is the final stage in which the semiconductor devices are constructed, necessary to connect a chip or IC: the chip is integrated into an electronic system such that it can function and reliably operate (electrically connected, manage generated heat, minimised environmental disturbance (noise, crosstalk, interference)). After that, the semiconductor devices are shipped to distributors (Nathan Associates Inc., 2016; Ciani & Nardo, 2022; Lammertink et al., 2023; OECD, 2019; Van Wieringen, 2022).
''Depending on the specific product, there are 400 to 1,400 steps in the manufacturing process of semiconductor wafers. The average time to fabricate semiconductor wafers is about 12 weeks, but it can take up to 14-20 weeks.'' (Semi-Literate, 2021). Each stage of production is highly specialized and competitive. The features of the chips must incorporate continuously evolving consumer preferences and differentiate the participant's contribution to the supply chain. Each step adds value. The end product containing a semiconductor becomes more competitive (Nathan Associates Inc., 2016).
In the Netherlands, industries are categorised into sectors. The Dutch semiconductor industry is assigned to the sector called 'High Tech Systems and Materials' (HTSM)[2] (G.Q. Zhang, May 26, 2023; Rijksoverheid, n.d.; Van de Burgt, 2017).

2.3 Dutch Stakeholders

The Dutch semiconductor industry involves various stakeholders: the semiconductor companies, industry associations, knowledge, R&D institutes, and the government (Lammertink et al., 2023). Also important are investors, venture capitalists, and financial institutions to support growth and innovation by providing funding, capital, and resources. The customers and end-users provide the market demand.
The Dutch semiconductor industry is relatively strong thanks to Philips which was one of the largest global electronic companies (Lammertink et al., 2023). The four biggest Dutch semiconductor

[1] A foundry is a company that offers semiconductor manufacturing services to other companies, while a fab is the physical facility where the manufacturing process takes place. Foundries can operate their own fabs or contract with other fabs (ASML, n.d.).
[2] '' The top sector High Tech Systems and Materials (HTSM) develops and produces high-quality end products, semi-finished products, components, materials and services for customers all over the world. Dutch high-tech products are intelligent, accurate and efficient, and are used worldwide in, for example, medical devices, semiconductor production, cars, logistics systems, aircraft, satellites and energy systems.'' (Rijksoverheid, n.d.)

companies are ASML, ASM International, BE Semiconductor Industries (Besi), and NXP[3] (K.A.A. Makinwa, May 26, 2023; G.Q. Zhang, May 26, 2023).
The semiconductor industry, in general, does not have clear boundaries. The list of companies directly or indirectly related to the chip industry is endless. It is easy to track listed companies, but hundreds of companies are not listed on the stock exchange and, therefore, not that easy to find. For example, ASML has 200 (local) suppliers for parts to build an average EUV[4] machine. All of which are indirectly related to the chip industry. According to one of the industry associations, the sector employed 15.000 people in 2019 (Lammertink et al., 2023). That number will grow because ASML intends to expand its employees in the Netherlands to 35.000 in the following years. Some companies based in the Netherlands are foreign-owned (Lammertink et al., 2023).

The Netherlands has two industry associations[5]; Holland Semiconductors and PhotonDelta. Holland Semiconductors is a national network of semiconductor companies in the Netherlands. And ''PhotonDelta is an association for the integrated photonics sector.'' The association is supported by the Dutch government, for example, through investments.'' (Lammertink et al., 2023).
The Netherlands has three technical universities with research groups related to microelectronics. These are TU Delft, the University of Eindhoven, and the University of Twente. Besides the universities, the Netherlands has several research and technology centres. TNO, the Holst Centre, the Chip Integration Technology Centre (CITC), and OnePlanet. These organisations provide applied R&D services for the sector (Lammertink et al., 2023).
The government is an important stakeholder as well. This group includes regional development companies and foreign companies that want to cooperate with players from the Netherlands, including in the semiconductor sector. Also included are the Rijksdienst voor Ondernemend Nederland (RVO), which supports innovations by companies in the Netherlands, and the Netherlands Foreign Investment Agency (NFIA), which supports foreign companies investing in the Netherlands to connect with Dutch companies (Lammertink et al., 2023).

2.4 Market position and Geopolitical scene

As mentioned, the semiconductor value chain is complex, with some very capital-intensive steps, and is global in scope. Manufacturers have come to rely on extensive networks of suppliers and contractors to perform specialised tasks at different stages of the chain. According to a briefing report by the European Parliament, a chip crosses the border 70 times during the complete supply chain. According to one estimate, a large US-based semiconductor company may have as many as 16,000 suppliers worldwide (Nathan Associates Inc., 2016; Van Wieringen, 2022). A limited number of countries

[3] ''ASML is by far the largest and most important Dutch semiconductor company. It manufactures the most high-tech semiconductor equipment: for example, ASML is the only company in the world with the capabilities to manufacture EUV machines necessary to produce the most advanced chips (smaller than 5nm). ASM International (ASMI) manufactures equipment used by front-end companies (for example, foundries) to produce chips. Besi is also active in the equipment industry. It produces equipment for the packaging segment of the value chain. NXP is the largest Dutch company that designs and produces semiconductors. The company does not focus on producing the smallest/most advanced chips, but specialises in chips with RF functionality'' (Lammertink et al., 2023). Most of NXP's income comes from the automotive and industrial/internet markets. The company also has a strong presence in communication infrastructure and mobile markets. It is the co-inventor of near-field communication (NFC) technology, which enables secure mobile payments and data exchange (NXP, 2022).
[4] AN EUV machine is a machine that uses extreme ultraviolet light lithography to produce chips.
[5] Industry associations include organisations representing and bringing together companies in the same sector. The main function of such an association is to promote the common interests of the companies in the sector.

dominate the chip production chain. Due to the high specialisation of companies, none of these countries is independent or autonomous in the entire chain (Ciani & Nardo, 2022). They lead in specific segments of the chain. This makes the semiconductor industry highly dependent on the free cross-border flow of parts, machinery, services, knowledge, and talent, increasing its susceptibility to supply chain disruptions.

The market typically goes through periodic booms and busts, driven by product innovations and market disruptions. The semiconductor industry has no single driver: the market is diversified, fragmented, and growing. Besides the early driver's mainframes, PCs and smartphones, IoT[6] (infrastructure), AI, Quantum computing, 5G and 6G, AR/VR[7], and automotive will push the industry for better solutions (Bown, 2020; European Commission, 2023c; Lammertink et al., 2023; Science Business, 2023). At the same time, the continuous advancement of chip technology plays a vital role in driving innovation across various industries and enabling the development of more powerful and efficient electronic devices. Technological innovation drives market demand and vice versa (European Commission, 2023c).

Another typical driver for the semiconductor industry is Moore’s law. In 1965, Gordon Moore, one of the Intel co-founders, predicted that the number of transistors on a chip - an indicator of chip performance - would double every two years. And it has, to the point where some semiconductors today have more than two billion transistors (OECD, 2019). Moore's law does not constitute a physical law; rather, it represents the economic implications of miniaturisation, innovating and enhancing the manufacturing processes to fit more circuitry onto a single chip, resulting in increased computational power. Moore’s law serves as a guiding principle and a driving force behind advancements in the semiconductor industry (Nathan Associates Inc., 2016; Huggins et al., 2022; The European Chips Act, z.d.; Zhang et al., 2023.

In 2020 global semiconductor sales totalled 410 billion euros, and 80% of that were IC sales. Sensors (such as microelectromechanical systems, MEMS), optoelectronics (such as LEDs), and discrete semiconductors (single transistors) together made up the remaining 20% of sales in the industry (Ciani & Nardo, 2022).

According to Ciani and Nardo (2022), the EU is a net importer of transistors, diodes, and similar semiconductor devices (mostly from China) and electronic integrated circuits (mainly from Taiwan). South Korea and Taiwan are world leaders in producing the smallest and most technically advanced chips. Both countries plan to build new manufacturing plants (fabs) in the United States so that the US might move up the ladder soon (Ciani & Nardo, 2022). The EU is a net importer of other inputs such as beryllium, chromium, germanium, vanadium, and gallium. EU companies rely on suppliers and customers outside the EU: on average, almost 80% of suppliers are headquartered outside the EU, and only 37% of EU customers are in the EU. Most foreign suppliers are in the United States, followed by Taiwan, China, South Korea, and Japan (Ciani & Nardo, 2022). For instance, one of the largest manufacturers, Taiwan Semiconductor Manufacturing Company (TSMC), and one of the key chip design companies, Nvidia, are located in Taiwan. Dutch companies are mainly at the beginning of the chain and have no relationship with the end customer (Semi-Literate, 2021).

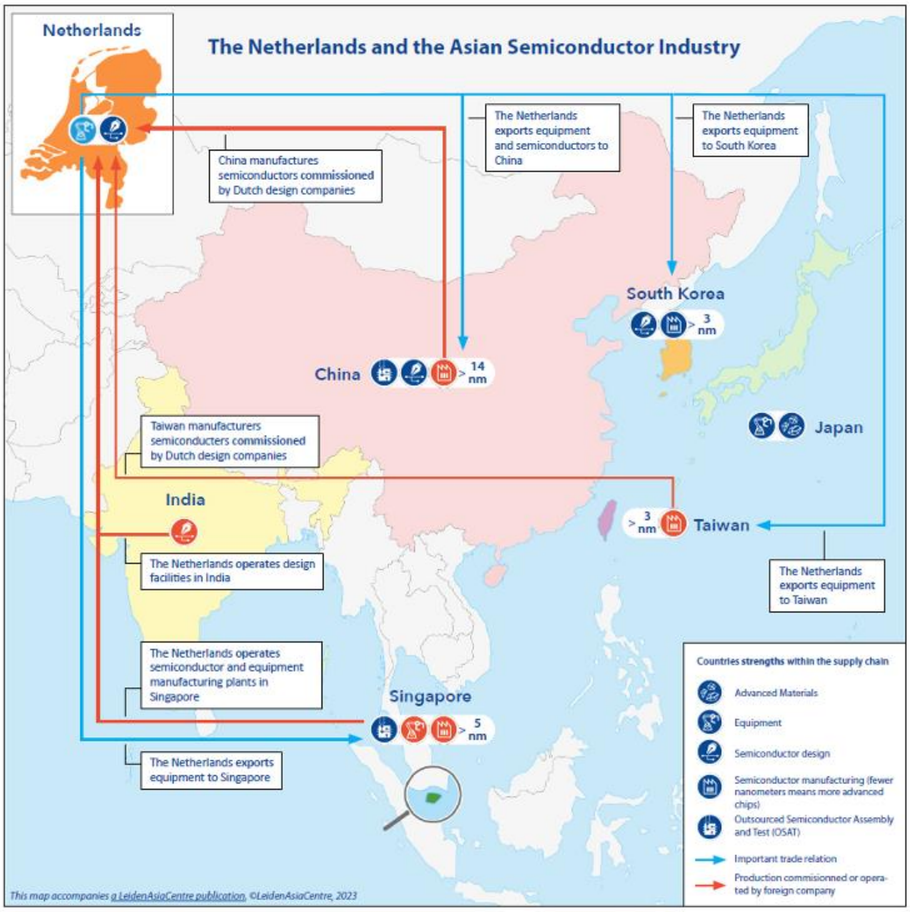
The Dutch semiconductor industry has several links with the Asian semiconductor sector. Figure 2 illustrates the Dutch semiconductor interests in Asia. The website of the Leiden Asia Center shows an interactive version of this map. ASML, NXP, ASMI, and Besi’s sales in China are significant: respectively 14.7%, 38%, 16%, and nearly 38% of their total revenue (Lammertink et al., 2023).

[6] Internet of Things

[7] Augmented and Virtual Reality

Figure 2

The Netherlands and the Asia semiconductor industry



Note: for the interactive version, use the link in the reference chapter under Leiden Asia Centre, n.d.

The semiconductor industry is strategically important for economies worldwide as semiconductors are essential components used in various electronic devices and technologies. Intense global competition, complex supply chains, and rapid technological advancements characterise the industry. The Covid-19 pandemic and increasing geopolitical tensions, in particular with China, stress the importance of supply chain resilience: a reliable and resilient supply of semiconductors (Aurik et al., 2022; Ciani & Nardo, 2022; Huggins et al., 2022; KPMG, 2020; The European Chips Act, z.d.; Zhang et al., 2023; Bish et al., 2022). In 2018, the Trump administration started several actions to frustrate China's goal for their semiconductor industry to become technologically highly advanced and self-reliant. President Biden continued these actions. In 2022, the 'CHIPS and Science Act' was signed into law, aiming to, amongst others, boost the American semiconductor industry, ensuring US "leadership in the technology that forms the foundation of everything from automobiles to household appliances to defence systems" (The White House, 2023). The administration is tying the bonds with Japan, South Korea, and Japan, and in October 2022, Biden introduced export controls targeting semiconductor-related supplies to China. Only recently, under US pressure, the Dutch government did not renew ASML's export license required to ship its most advanced EUV machine to China (Nellis, 2020).

3. THEORETICAL FRAMEWORK

The question ''What mode of governance fits best for the Dutch semiconductor industry to use the opportunities provided by the EU Chips Act to improve its market position?'' requires knowledge of both the semiconductor industry and the policy context of the European Chips Act and expertise in 'modes of governance.' The question implies a relationship between the opportunities provided by the European Chips Act and the Dutch semiconductor industry's position in the global market. The research aims to explain this relationship and how the industry can leverage it to improve its position. This research will be done using the following theoretical frameworks.

3.1 SWOT and Porter

Understanding the Dutch semiconductor industry is essential to answer the different sub-questions. The Porter and SWOT models will depict the Dutch semiconductor industry.

The SWOT and Porter models are widely used frameworks in business strategy. While they have different approaches, they both aim to analyse a company or industry and its competitive position comprehensively (Schooley, 2023).

The SWOT model considers two internal and two external key elements, being (1) Strengths: internal factors that give the company a competitive advantage, (2) Weaknesses: internal factors that limit the company's ability to compete, (3) Opportunities: external factors that the company can capitalise on and (4) Threats: external factors that could negatively impact the company's performance (Schooley, 2023).

The Porter model focuses on analysing the external competitive forces that shape an industry. The model considers five competitive forces: (1) threat of new entrants, (2) intensity of rivalry among existing firms, (3) threat of substitute products or services, (4) bargaining power of buyers, and (5) bargaining power of suppliers (Porter, 1980). Where the SWOT model focuses on internal and external factors specific to the sector, the Porter model focuses more on the external environment and competition. In combination, the SWOT and Porter models provide a comprehensive analysis of the Dutch semiconductor industry related to and within the dynamics of its global environment.

3.2 Mode of governance

'Mode of governance' refers to the underlying logic recognised in governance practices (Bouwma, 2015). In this thesis, two frameworks are combined to identify the governance mode used in the Dutch semiconductor industry, The framework of Bouwma (2014) and the framework of Van Heffen and Klok (2000). In the framework of Bouwma, four types of governance modes are identified: (1) hierarchical governance, (2) network governance, (3) market governance, and (4) knowledge governance. Hierarchical governance refers to a top-down approach to decision-making, where power is concentrated at the top of the organisation or government (Meuleman, 2010). Network governance refers to collaboration and cooperation among stakeholders, such as businesses, government agencies, and civil society organisations, to achieve shared goals (Bouwma, 2015). Market governance refers to using market mechanisms, such as competition and pricing, to influence behaviour and achieve desired outcomes (Bouwma, 2015). Finally, knowledge governance refers to how knowledge is created, shared, and used within organisations and societies. (Bouwma, 2015). It refers to how organizations and societies create, share, and use information. Knowledge governance focuses on managing, creating, disseminating, and using knowledge within organizations, networks, or societies. It encompasses the rules, norms, and processes that guide how knowledge is accessed, shared, and utilized. Knowledge governance ensures the quality, availability, and effective utilization of knowledge resources. It is not limited to the governance of a specific resource like knowledge but rather encompasses a broader perspective on knowledge management and its impact on decision-making, innovation, and organizational performance. It recognizes that knowledge is a valuable asset that needs to be governed and leveraged effectively to support individual and collective goals.

Van Heffen and Klok (2000) distinguish three governance modes (state models); multi-centric (market models), uni-centric (hierarchy model), and pluri-centric (network model).
Market governance (multi-centric model) suggests that power is distributed among various actors. There are sellers and buyers; there is free entry for these buyers and sellers; there is a freedom to act on your property limited only by constitutional and general legal; the aggregation is bilateral agreements and spontaneous through individual action and price setting. The actors in this model have a personal interest. Hierarchical governance (uni-centric model) implies that power is concentrated in a single entity. The crucial positions can be defined as the authorities and the citizen. The authorities represent the state, whereas the other stakeholders in the sector are subject to state control but are also offered state protection (Van Heffen & Klok, 2000). In this mode, the authorities are free to make decisions assigned to the position by constitutional legal rules in accordance with procedures. The citizens are free to use civil rights and have relationships with the authorities. The authorities decide based on constitutional rules. The authorities in this mode have a common interest, and the citizens have a personal interest (Van Heffen & Klok, 2000).
As is implied by the name, network governance (pluri-centric model) might contain a large number of positions. Still, when focusing on the characteristics of the model as a network, the main positions can be called the network members (those who are in) and the non-members (those who are out). The authority of the members lies mostly with collective decisions; the non-members have no specific authority within the sector or the sector's value chain. The aggregation is based on consultation and multi-actor agreement and is conducted chiefly through spontaneous individual actions. The actors in this mode have both individual and a mix of common interests.

3.3 Policy instruments

Where the mode of governance is based on coordinative principles, regardless of the targeted actors, the policy instruments are the tools of the government for implementing their policy (Bouwma et al., 2015) and are dedicated to the target group.

According to Bouwma, ‘’policy instruments are developed by the government to implement their policies and influence the behaviour of citizens and businesses’’. There are different policy instrument types: (1) legislative /regulatory instruments, (2) economic/fiscal instruments, (3) agreement based/cooperative instruments, (4) (traditional) information/communication-based instruments, and (5) knowledge instruments (Bouwma, 2015). The report will address all these policy instruments and how they are included in the EU Chips Act.

4. METHODES

4.1 Research design

This research investigates what governance mode can be used fot the Dutch semiconductor industry to enhance its global position by leveraging the opportunities provided by the European Chips Act. A qualitative research design, specifically a literature review, is employed to explore the complex dynamics of the semiconductor industry and the potential impact of the European Chips Act. As stated by Snyder (2019), building research upon and relating it to existing knowledge forms the foundation of all academic research activities, regardless of discipline. Snyder also describes a literature review as a systematic way of collecting and synthesizing previous research that can answer research questions with a depth that no single study can reach.

This Bachelor's thesis employs a semi-systematic literature review, aiming to understand all related research traditions that could affect the study, synthesizing them via meta-narratives. The approach is a blend of systematic and non-systematic methodologies, following a structured process while allowing flexibility in data collection and analysis. The research, exploratory and descriptive, hinges on expert interviews to guide literature selection, focusing on the status of the Dutch semiconductor industry relative to the EU Chips Act.

4.2 Data collection

Data is collected via a comprehensive literature search using predefined search criteria and relevant databases. The search aims to identify existing studies, reports, and articles relating to the Dutch semiconductor industry, its governance, the European Chips Act, and opportunities for improvement.

In addition to the literature review, expert interviews are conducted to gain qualitative insights from industry professionals. These interviews indicate specific areas to focus on within the literature review. Interviews are preferable to surveys or questionnaires as they allow for detailed responses, follow-up questions, and in-depth exploration of topics.

The chosen interviewees meet criteria, including expertise in the field, diversity of perspectives, relevance to the Dutch semiconductor industry, representation of stakeholders, and availability and accessibility.

Ethical considerations such as obtaining informed consent, ensuring confidentiality, and, if requested, maintaining participant anonymity are strictly adhered to throughout the study.

4.3 Data analysis

The data analysis involves textual analysis, particularly content analysis. It focuses on various aspects, such as the semiconductor industry's strengths, weaknesses, and threats (using the SWOT and Porter model), the regulatory framework, government policies, industry practices, and specific provisions of the EU Chips Act relevant to the Dutch semiconductor industry.

I use a coding scheme to identify and categorise themes and concepts from the collected literature and interviews. I defined several subcodes within each category, further refining the respective class's themes or concepts. I linked each code and subcode to the corresponding source(s), contributing to the research's traceability and transparency.

Originally, I intended to use the software Atlas.ti for data management and analysis. However, due to the complexity of this software and the limited time and resources available for this undergraduate project, I chose not to proceed. Instead, I opted for a manual approach, applying the codes and subcodes directly into an Excel sheet to organise and analyse the data. Although less automated, this approach allowed me to develop a detailed and in-depth understanding of the themes under study. Multiple sources corroborating a strength validates its accuracy. Interviews are used not as quantitative data but as insights. The coding scheme is represented in Appendix A.

5. RESULTS

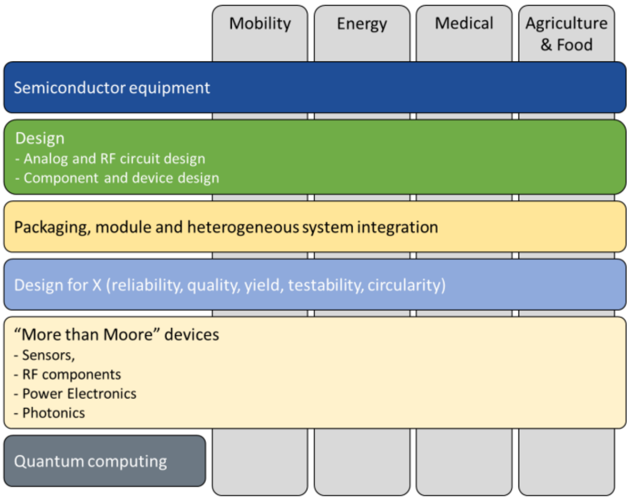
5.1 Strengths and weaknesses

This section will discuss the strengths and weaknesses of the Dutch semiconductor industry. And answer the question: What are the current strengths and weaknesses of the Dutch semiconductor industry?

Dutch position

Thanks to trailblazers like Philips, the Netherlands hosts a robust semiconductor industry, housing companies and institutes that represent the entire value chain, from R&D to chip manufacturing and application design (Lammertink et al., 2023). Its semiconductor cluster, featuring prominent firms such as ASML, ASMI, BESI, and NXP, and a wide range of SMEs designing, testing, and using semiconductor components in diverse sectors, is unparalleled (Lammertink et al., 2023). Multinationals like NXP Semiconductors, Philips, and Thales, along with equipment providers and research institutions, consolidate this unique ecosystem (High Tech NL, n.d.; Zhang et al., 2023).
In the past five years, this sector has grown significantly. As of October 2022, it constituted 24% (€276 billion) of the market capitalisation of all listed Dutch companies, up from 8% five years prior. Venture capital investment grew from around €20 billion in 2019 to €110 billion in 2022 (Ciani & Nardo, 2022; Hayes, 2023; Shopify, 2022; State of Dutch Tech, 2023). As of 2019, the sector employed over 15,000 people (Lammertink et al., 2023).

Figure 3
Key technology and application matrix for the Netherlands



Note: provides an overview of areas in which the Netherlands has a leading position worldwide and needs to develop further in terms of technology and application (Zhang et al., 2023).

European and global position
In 2022, NXP generated over 13 billion U.S. dollars (11,8 billion euros) in revenue, representing 2% of the global revenue (562 billion euros) and almost 25% of the European revenue (48 billion euro). (Baron, 2023). ASML is the largest supplier of photolithography systems for the semiconductor industry worldwide, generating revenues of around 21 billion euros in 2022 (Baron, 2023).
ASMI and Besi generated revenues of just over 2 billion euros and more than 700 million euros in 2022 (Baron, 2023).

So, the largest four companies in the Netherlands made over 35,5 billion euros in revenue in 2022. Compared to the European revenue of 48,2 billion euros and the global 562,3 billion euros, this translates to 73,7% and 6,3%.

Research and development

This sector's total private R&D investment is estimated to be over 1 billion euros, more than one-sixth of the Dutch private R&D (Holland High Tech, 2019). Kieckens (2021) states semiconductors are “a high-value industry with a high entry barrier.” Maintaining the leading market position is crucial. If you sink, reclaiming your position is very difficult.” The Netherlands ranks 5th on the 2022 global innovation index published by the UN (WIPO, 2022). Just behind Switzerland, the United States, Sweden, and the United Kingdom. The Netherlands has a relatively small government budget allocated for R&D compared to other countries ranked high on the global innovation index. Both the US and the UK have higher budgets. The University of Eindhoven has the most science and technology-intensive clusters compared to the other universities (TU Delft and the University of Twente)(WIPO, 2022).

The Dutch semiconductor industry has developed into a major global technology and electronics player, significantly contributing to the Dutch economy. With a strong focus on innovation and advanced manufacturing processes, the industry has built a solid reputation in semiconductor manufacturing, chip design, and system integration. (K.A.A. Makinwa, May 26, 2023; G. Q. Zhang, May 26, 2023; S. Nihtianov, May 22, 2023; T. Tiek, May 11, 2023)

5.1.1 SWOT model

In this paragraph, the SWOT model is used to evaluate the internal strengths and weaknesses of the Dutch semiconductor industry and the external opportunities and threats it faces.

Strengths

Regarding strengths, the Dutch semiconductor industry boasts a worldwide reputation for **chip design** and **research collaborations** with leading companies (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021; Zhang et al., 2023). The country's **excellent universities**, such as Delft, Eindhoven, and Twente, produce **highly trained professionals** specifically for the semiconductor industry (K.A.A. Makinwa, May 26, 2023). The Ministry of Economic Affairs agrees that the scientific level in the Netherlands of knowledge institutions, research institutes, and industry in the field of semiconductors is high (Ministerie van Economische Zaken en Klimaat, 2021).

The high scientific level in the Netherlands, coupled with **the strong connection between universities and companies**, further contributes to its strengths (KPMG, 2020; Lammertink et al., 2023; Ministerie van Economische Zaken en Klimaat, 2021; Zhang et al., 2023). The ability to collaborate and develop ecosystems is a distinguishing factor, particularly when compared to other countries where this aspect is less prevalent, particularly in Asian countries. Prime examples of successful ecosystems include those surrounding ASML and CITC, a collaboration between companies (NXP, Ampleon, Nexperia), knowledge institutions (TNO, universities), and the government (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021). Professor Guo Qi Zhang (2023, May 26) mentioned that the Netherlands' semiconductor ecosystems lie around the three technical universities. A study by Reg Brennenraedts et al. (2020) shows that the high level of research and commitment to public-private partnerships contribute to this. In addition, there are collaborations with foreign parties, such as the intensive collaboration between ASML and IMEC (ASML, 2022). ASML also has good customer relationships, as evidenced by the co-investment of Intel, Samsung, and Taiwan Semiconductor in developing ASML's EUV technology.

Moreover, the Netherlands **excels in certain semiconductor technologies**, particularly in the automotive sector, with active companies like NXP and Nexperia (G.Q. Zhang, May 26, 2023). T. Tiek (T. Tiek, May 11, 2023) highlights the expertise of the Dutch semiconductor industry in RF and analog chip design, particularly in the Twente region. And professor Makinwa mentions the critical role Dutch

companies and institutions have played in the development of standards and products such as Bluetooth and Wi-Fi (K.A.A. Makinwa, May 26, 2023).
Furthermore, the Netherlands excels in photonics, producing photonic chips based on light (photons) rather than electrons. Smart Photonics, a market leader in this field, received a €35 million public-private investment in 2020 to prevent foreign acquisition. Although the market for photonic chips remains limited, the expertise and potential are evident (KPMG, 2020).
The industry's strengths also extend to the **supply of equipment for chip manufacturing**, with significant contributions from companies like ASML, ASMI, NXP, and BESI (K.A.A. Makinwa, May 26, 2023; Zhang et al., 2023)). The SWOT analysis of KPMG (2020) endorses this strength: the previously mentioned strong ecosystem surrounding ASML monopolizes the lithography/chip machine industry. ASML is the only global entity capable of building EUV lithography machines that produce high-quality chips (ASML, 2022). This establishes the Netherlands as a powerhouse in machine building.

In December 2022, the Netherlands Academy of Technology and Innovation wrote a report for the Dutch Ministry of Economic Affairs to define an NL Chip Act plan (Zhang et al., 2023). The 'Report towards an NL chip plan' identifies six fields in which the Netherlands holds a **strong technology position**: (1) Semiconductor equipment, (2) advanced device and Analog and RF circuit designs, component and device design, (3) packaging, module, and heterogeneous system integration[8], (4) designing for X (reliability, quality, yield, testability, circularity), (5) "More than Moore"[9] devices: sensors, RF components, power electronics, photonics, and lastly, (6) quantum computing.

The strengths of different regions in the Netherlands within the semiconductor industry are also recognized. Eindhoven excels in equipment, Twente specializes in chip design (analog chips, MEMS, microfluidics), Nijmegen is home to multinational companies from the Philips legacy, and Delft leverages expertise from its university, including its cleanroom facilities (T. Tiek, May 11, 2023). Every region has individual plans, but they are also connected to a broader national plan, which poses specific challenges.

The Netherlands' semiconductor industry enjoys a powerful position due to its technological strength in particular semiconductor fields, research collaborations, equipment manufacturing, photonics, and strong ecosystem development. The country's universities and their alignment with the industry and successful partnerships and collaborations further cement its strong position.

Weaknesses
Various interviewees have identified several weaknesses within the Dutch semiconductor industry. One significant weakness is the **absence of semiconductor manufacturing facilities** in the country. While the industry focuses on design and research, the lack of manufacturing capabilities hampers its competitiveness in the global market (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021; K.A.A. Makinwa; G.Q. Zhang, May 26, 2023). According to professors Makinwa and Zhang,

[8] Heterogeneous systems combine different types of semiconductor technologies or materials. In traditional semiconductor systems a single semiconductor material (typically Si) is used, whereas in heterogeneous systems different materials, such as silicon, gallium nitride (GaN), or gallium arsenide (GaAs) can be integrated into a single system. This enables the combination of distinct functionalities, creating opportunities for new innovations and high-performance devices with diverse functionalities.
[9] The term "More than Moore" (M2M) is used to indicate a category of semiconductor devices that go beyond the traditional scaling of Moore's Law. Whereas Moore's Law refers to the continuous shrinking of transistor sizes to increase computational power, M2M devices focus on integrating additional functionalities and features onto semiconductor chips rather than solely relying on scaling.
Developing M2M devices requires interdisciplinary expertise in various areas, including semiconductor manufacturing, materials science, circuit design, packaging, and system integration (Zhang et al,. 2023).

Europe must retain some manufacturing capabilities to ensure regional security and prevent disadvantages on the global landscape (K.A.A. Makinwa, May 26, 2023; Guo Qi Zhang, May 26, 2023).

The **fragmentation of the semiconductor industry** across different regions in the Netherlands, each with its specialized strengths, also presents challenges. Lack of coordination and collaboration hinder sharing of knowledge, resources, and best practices, to competition for funding, market share, talent, etc., limiting overall growth and competitiveness of the Dutch semiconductor sector. Moreover, regional programs might hinder national collaboration (T. Tiek, May 11, 2023).
On an individual company level, KPMG (2020) mentions that ASML's extreme focus on its core activities limits opportunities for other ventures or spinoffs. Given ASML's unique capabilities, this limitation is seen as a missed opportunity for the manufacturing industry in the Netherlands, as it could potentially stimulate new initiatives.
The Dutch semiconductor industry might benefit from more influential companies to **increase European funding** (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021). Professor G.Q. Zhang (2023, May 26)cites Finland as an example of a country dominating European public funding programs for semiconductors.

The weaknesses identified in the Dutch semiconductor industry include the absence of manufacturing facilities, the fragmentation or lack of collaboration, and foster the growth of influential companies to increase the amount of European funding. Addressing these weaknesses will be crucial to maintain and enhance the industry's competitiveness in the Netherlands.

Opportunities
The Dutch semiconductor industry has several opportunities for growth and innovation. The Netherlands has a solid manufacturing base and expertise in high-tech industries. This presents an opportunity for Dutch semiconductor companies to capitalize on their advanced manufacturing capabilities and **offers specialised semiconductor manufacturing services** to domestic and international clients.
Another opportunity is the proximity to key markets. The Netherlands is strategically located close to major European markets, such as Germany, France, and the United Kingdom. This geographical advantage gives Dutch semiconductor companies easy access to these markets, enabling them to establish strong customer relationships and **expand their market share in Europe and the United Kingdom**.
The strong ecosystem for collaboration and innovation provides an opportunity as well. The Netherlands boasts a well-established ecosystem of research institutes, universities, and industry players that actively collaborate and share knowledge (K.A.A. Makinwa, May 26, 2023; G.Q. Zhang, May 26, 2023). The semiconductor industry can **leverage more of the collaborative environment,** fosters innovation, and present opportunities to engage in joint research projects, access funding, and leverage expertise from various stakeholders (Zhang et al., 2023).
The Dutch government and private organizations provide **support programs, funding, and resources specifically designed to foster the growth of startups and scale-ups** in the semiconductor industry. These initiatives create opportunities for Dutch semiconductor startups to receive financial backing, mentorship, and access to networks that can help them thrive and compete globally (Zhang et al., 2023; KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021).
KPMG (2020) identifies several growth markets that offer large potential for the Dutch semiconductor industry. **Metrology**, which involves precise measurement and testing of chip machine results, is one of them.
Autonomous driving presents another significant opportunity. It requires specialist chips, which are expected to come from Europe. Germany, France, and NXP are identified as important players in this area (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021). The production of **photonic chips** is recognized as a potential industry for the Netherlands, provided there is sufficient investment in its development. Currently, the market for photonic chips is limited in size.

Quantum technology is also identified as a chance for the Dutch semiconductor industry (KPMG, 2020; Ministerie van Economische Zaken en Klimaat, 2021). The ecosystem surrounding ASML is considered a logical environment for building quantum computers (KPMG, 2020). Furthermore, the trade conflict between Japan and South Korea could mean increased exports from the Netherlands to South Korea.

Threats

The Dutch semiconductor industry faces several challenges and threats that must be addressed. One of the challenges is the technical risks associated with producing advanced chips with high performance and meeting market demands and competition (S. Nihtianov, May 22, 2023).

Another threat highlighted by Prof. Dr. Kofi Makinwa (May 26, 2023) is the need for improved outreach, particularly in education. He points out the **shortage of qualified (young) people** (FD, 2017; IMEC, 2019; Zhang et al., 2023) and the need for improved output, particularly in education. He emphasises the importance of encouraging more students, especially girls, to choose technical and engineering fields. Other countries' aggressive investments in chip-related education and vocational courses further exacerbate this talent shortage.

All interviewees acknowledge the shortage of tech workers and the negative consequences for further growth. The report of Zhang et al. (2023) also discusses the talent shortage in the semiconductor industry. It emphasizes addressing this shortage by implementing comprehensive education and training programs. The report estimates that Dutch semiconductor-related companies will require thousands of graduates at various levels each year to achieve their growth ambitions in the Netherlands. Urgent action is needed to solve the shortage problem, suggesting a collaboration between educational institutions and semiconductor companies to develop national semiconductor education programs. Increasing educational capacity, including staff and infrastructure, is crucial, focusing on doubling the number of graduates at the academic level, requiring a proportional increase in professors and Ph.D. students (Zhang et al., 2023).

Global competition poses a significant threat to the Dutch semiconductor industry. Dutch companies must stay at the forefront of technological advancements and maintain their competitive edge to avoid being overshadowed by global competitors (K.A.A. Makinwa, May 26, 2023).

KPMG (2020) notes that the Netherlands provides relatively **less government support** to the semiconductor industry than countries like France and Germany. The interpretation of existing EU regulations regarding tenders is suggested as a possible reason for this disparity, although further investigation is required (KPMG, 2020). Also, the existing **fiscal measures** in the Netherlands are considered to be less active in promoting innovation compared to the measures taken by Germany.

While beneficial, the dominant position of ASML also means that the Netherlands is susceptible to losing market share. The emergence of **alternatives that can compete for market share** is a concern, especially in the lower-end market segment, where cheaper chips with less capacity are being produced (KPMG, 2020). Public-private investments can be a means to stimulate such innovations (KPMG, 2020).

Geopolitical factors, such as US export policies to China, can harm the market demand for Dutch semiconductor products. Moreover, these factors can accelerate the emergence of alternatives as other countries heavily invest in (semiconductor) technology (KPMG, 2020).

To concluse, to overcome these challenges and threats, the Dutch semiconductor industry needs to enhance talent development to address the shortage of qualified people and closely monitor and actively respond to evolving global competition and geopolitical dynamics.

5.1.2 Porter model

The Porter model focuses on analysing external competitive forces a company or sector experiences and that shape the sector. The intense competition from major players in countries like the United States, Japan, Taiwan, and South Korea increases the rivalry among semiconductor companies. Dutch

semiconductor companies must differentiate themselves through technological advancements, product innovation, and superior value propositions to stay competitive.
The challenge of attracting and retaining skilled engineers is one of the elements of this competition. **The scarcity of skilled talent** gives these professionals **bargaining power** (one of the five forces identified by Porter), as they can choose among different job opportunities and negotiate the best terms. Semiconductor companies must invest in talent development, provide attractive incentives, and create a positive work environment to mitigate this threat.
Buyers, especially **large customers**, also hold significant bargaining power. They can negotiate prices, demand customization, and switch suppliers if their demands are not met. **Competing with low prices** in Asia is challenging, especially for companies in or related to the manufacturing phase and supply of chemicals (S. Nihtianov, May 22, 2023). Semiconductor companies must understand customer requirements, provide excellent customer service, and continually innovate to maintain customer loyalty and mitigate this threat. The semiconductor industry relies on suppliers such as manufacturing equipment companies, specialized chemicals and materials suppliers, and EDA software providers. These suppliers may have some bargaining power due to their specialised nature and limited alternatives. Semiconductor companies should carefully manage their relationships with suppliers to ensure a reliable supply chain and favourable terms.
The threat of **substitute products or services**, another force Porter identified, also affects the semiconductor industry. Technological advancements and disruptive innovations can potentially render certain semiconductor products obsolete. To address this threat, semiconductor companies must invest in research and development, stay informed about technological trends, and continuously innovate to stay ahead of substitutes and maintain their market position (S. Nihtianov, May 22, 2023).

So to answer the question; what are the current strengths and weaknesses of the Dutch semiconductor industry? The Dutch semiconductor industry sees several notable strengths, such as its global reputation for chip design, high-quality universities and research collaborations, strong ecosystem development, and specific technological prowess in certain areas. However, the industry also deals with significant weaknesses, including the absence of manufacturing facilities, fragmentation and lack of collaboration across different regions, and the need to get more influential companies for attracting European funding. Addressing these weaknesses while capitalizing on the opportunities presented by growth markets like metrology, autonomous driving, and quantum technology will be vital. Yet, the industry also faces threats, such as the technical risks associated with chip production, talent shortages, global competition, and geopolitical dynamics.

5.2 Characteristics mode of governance of the Dutch semiconductor industry

The Dutch semiconductor industry operates within a governance landscape involving multiple stakeholders and governance modes, including hierarchical, market, network, and knowledge. These different modes of governance shape the industry's operations and outcomes, creating a complex and dynamic environment.

5.2.1 Market governance

The EU strongly appreciates market governance and aims to create open markets that promote innovation and competitiveness while discouraging anti-competitive practices (Raider, 1998). The EU's regulatory framework ensures fair competition and prevents market dominance by a single player, fostering an environment where companies can thrive based on their merits.

The Dutch semiconductor industry operates within a market-driven framework, where supply and demand dynamics are influenced by technological advancements, market trends, and global economic conditions (see Chapter 2). Competition drives the semiconductor industry, as multiple companies offer similar products and services (T. Tiek, May 11, 2023). This dynamic nature means that companies

must continually adapt to changing circumstances, anticipating customer needs and staying abreast of market developments (Raider, 1998). By staying competitive and responsive, companies can maintain their market position and meet the evolving demands of consumers.
Several key players contribute to the market governance within the Dutch semiconductor industry. ASML, for instance, is dominant in the market with its advanced lithography systems (Bordoloi, 2022). These systems are highly sought after by semiconductor manufacturers worldwide due to the continuous need for cutting-edge technologies in producing integrated circuits. NXP Semiconductors, on the other hand, offers a diverse portfolio of reliable chips catering to various industries such as automotive, IoT, and mobile devices (NXP, 2022). Their products are in high demand, further fuelling market dynamics.
Thermo Fisher Eindhoven, a Thermo Fisher Scientific subsidiary, supplies semiconductor testing, and measurement equipment. By operating within a market-driven environment, they strive to meet the evolving demands of semiconductor manufacturers and contribute to the industry's growth (Brainpot Eindhoven, n.d.). Similarly, companies like Besi and ASMI play significant roles in the semiconductor assembly and packaging equipment sector, offering innovative solutions that meet the demand for advanced packaging technologies (High Tech NL, n.d.; KPMG, 2020; Lammertink et al., 2023).

In summary, market governance in the Dutch semiconductor industry thrives on and drives competition, innovation, and market-driven dynamics. Companies within this industry operate within a competitive framework, responding to customer demands and continuously improving their offerings (Raider, 1998). The combination of market-driven dynamics and EU regulations helps to create a fair and competitive landscape that promotes innovation, efficiency, and customer-driven solutions (Raider, 1998). The Dutch semiconductor industry can benefit from increased competition by adhering to market governance principles, leading to technological advancements, improved customer experiences, and overall industry growth.

5.2.2 Hierarchical governance

Hierarchical governance is a prominent aspect of the Dutch semiconductor industry: it occurs within the different companies and institutes, and at the same time, these companies and institutes are also part of an external hierarchy.
Companies within the industry have well-defined hierarchical organisational structures that facilitate effective coordination, resource allocation, and the implementation of strategic goals (Lammertink et al., 2023). Decision-making authority flows from top-level executives to middle managers and lower-level employees, ensuring smooth operations and efficient management (Lammertink et al., 2023). This hierarchical structure extends to various aspects of the industry, such as research and development activities, manufacturing processes, and regulatory compliance.
In the R&D domain, semiconductor companies follow hierarchical governance by organising research teams and departments under senior researchers' or technical leads' guidance and supervision. This hierarchical structure ensures a systematic approach with clear roles, responsibilities, and reporting lines, enabling efficient R&D processes and innovation (Lammertink et al., 2023; OECD, 2019; Raider, 1998).
Similarly, manufacturing processes in the semiconductor industry are organized hierarchically, with different stages and tasks allocated to specific teams or individuals. This hierarchical structure ensures efficient coordination, quality control, and adherence to production schedules, contributing to the overall success of semiconductor manufacturing operations (Lammertink et al., 2023).
Regulatory compliance is also supported by hierarchical governance within the industry. Semiconductor companies establish internal control systems, assign compliance officers, and follow hierarchical structures to ensure legal and industry requirements adherence. This approach helps maintain product quality, safety, and compliance with applicable regulations, promoting trust and reliability in the industry (Lammertink et al., 2023).

Furthermore, industry associations or trade organisations related to the Dutch semiconductor industry also operate with hierarchical governance. These associations have elected or appointed leaders who make decisions on behalf of their members. By providing a platform for collaboration, information sharing, and representation of common interests, these hierarchical structures contribute to the collective growth and development of the industry (Lammertink et al., 2023).

At the same time, the semiconductor industry is part of Dutch society and the subject of the Dutch government's policies and initiatives. These policies often align with EU plans and focus on promoting high-tech sectors, including semiconductors (Keijzer, 2020). The Dutch government provides fiscal incentives to encourage R&D activities and attract skilled personnel (Lammertink et al., 2023).

The European Commission (EC) plays a vital role in shaping policies for the semiconductor industry, including the establishment of the Industrial Alliance on Processors and Semiconductor Technologies in 2021, fostering cooperation among EU stakeholders for more secure and competitive semiconductor technologies (European Commission, 2023b). The EC has also implemented a broad semiconductor strategy to bolster its global position and foster research, innovation, and supply chain resilience. Key initiatives like the EU Chips Act and funding programs such as Horizon Europe support these efforts. Additionally, the EC enforces frameworks to ensure fair competition, regulate trade, and protect intellectual property within the industry (European Commission, n.d.).

The internal hierarchical governances facilitate the semiconductor's operations and success. The Dutch government's policies, initiatives, and EU-level strategies and funding further shape the industry's development and success (Lammertink et al., 2023; Keijzer, 2020; European Commission, n.d.).

5.2.3 Network governance

Supply chain networks are part of the network governance of the Dutch semiconductor industry. Professor Guo Qi Zhang mentions the High Tech Systems and Materials (HTSM) sector plan, which organises the high-tech sector, including semiconductors, from a government perspective. However, he notes the absence of a formal governance structure making collective decisions for the industry (G.Q. Zhang, May 26, 2023). Instead, the Dutch semiconductor industry thrives on strong networks established among research institutes, universities, industry players, and government entities (T. Tiek, May 11, 2023).

According to Dr. Stoyan Nihtianov (May 22, 2023), the Dutch semiconductor industry comprises a few primary chip production and equipment supply players. While competition exists, these players also cooperate to advance the development of next-generation machines and chips. These networks serve as platforms for knowledge sharing, collaboration on research and development projects, and exchanging expertise (Lima et al., 2022). Close interaction and cooperation among stakeholders promote innovation, foster technological advancements, and collectively address shared challenges (Lima et al., 2023).

International collaborations and partnerships are crucial elements of network governance. Dutch semiconductor companies partner with global counterparts to access international markets and expand their reach (Huggins et al., 2022). For instance, BESI, a global leader in semiconductor assembly equipment, establishes connections with national and international suppliers, manufacturers, and distributors to ensure smooth material flow and optimize production processes.

In general (inter)national networks facilitate technology transfer, market expansion, and the exchange of best practices, contributing to the growth and competitiveness of the Dutch semiconductor industry.

The Dutch semiconductor industry is clustered in several regions. Eindhoven, known as Brainport Eindhoven, is one of these clusters. It houses numerous high-tech companies, research institutions, and universities, with a strong focus on innovation in the semiconductor industry. Companies like NXP Semiconductors, ASML, and Royal Philips contribute to developing new technologies (Stam et al., 2016; Brainport Eindhoven, n.d.). Eindhoven plays a significant role in research and development, accounting for a considerable portion of total Dutch R&D investment (Statistics Netherlands, 2020). This region exhibits a higher R&D expenditure by Dutch-based enterprises and a concentration of high-tech components and equipment (Romme, 2022).
Another notable cluster in the Dutch semiconductor industry is ChipTech Twente. It serves as a network hub, bringing together companies, research institutes, universities, and governmental organizations with a shared focus on semiconductor technology. ChipTech Twente collaborates with the University of Twente, Saxion University of Applied Sciences, and several regional high-tech companies, explicitly focusing on micro- and nano-electronics. This cluster provides services and facilities for developing new semiconductor technologies, including access to state-of-the-art equipment and design, fabrication, and testing expertise (T. Tiek, May 16, 2023).

Furthermore, Dutch Semiconductors and PhotonDelta represent collectives of semiconductor-related companies, research institutes, and knowledge centers across the Netherlands. These networks facilitate cooperation, joint initiatives and support the growth and competitiveness of the Dutch semiconductor industry on both national and international levels. High Tech NL, another industry association, brings companies, knowledge institutes, and government organizations together to collaborate on research, development, and knowledge sharing. These networks are vital in addressing industry challenges and advancing the semiconductor sector.

5.2.4 Knowledge governance

The semiconductor sector is knowledge-intensive. Logically, knowledge governance plays a crucial role in the Dutch semiconductor industry. It facilitates the management, sharing, and protection of valuable knowledge and intellectual property within the sector. It encompasses various mechanisms and practices to enhance knowledge creation, acquisition, transfer, and utilization. All very important given the fierce global competition.
One specific application of knowledge governance in the Dutch semiconductor industry is through research collaboration and knowledge sharing among stakeholders, including government agencies, research institutes, universities, and private firms. These entities engage in joint research projects, knowledge exchange programs, and partnerships to leverage their collective expertise and resources. By sharing knowledge, best practices, and technological advancements, they accelerate innovation and foster the development of cutting-edge semiconductor technologies (Lammertink et al., 2023; Zhang et al., 2023).
Furthermore, knowledge governance is evident in protecting intellectual property rights within the industry. Semiconductor companies invest significant resources in research and development, creating proprietary knowledge, patents, and inventions. Knowledge governance ensures that appropriate legal and contractual mechanisms are in place to safeguard these intellectual assets and prevent unauthorized use or infringement. Additionally, knowledge governance addresses ethical considerations and responsible knowledge management practices. It involves ensuring compliance with confidentiality agreements, non-disclosure agreements, and ethical guidelines to protect sensitive information and maintain the trust and integrity of the industry.
In addition, knowledge governance in the Dutch semiconductor industry involves establishing knowledge management systems and processes. These systems enable effective capture, organization, storage, retrieval, and dissemination of critical knowledge and information. It includes the

development of databases, repositories, and knowledge-sharing platforms that facilitate seamless access to relevant technical documentation, design specifications, manufacturing processes, and other valuable knowledge assets.
Knowledge governance also encompasses training and skill development initiatives to enhance the competencies and expertise of professionals within the semiconductor industry (Stam et al., 2016). This may include specialized training programs, workshops, and knowledge-sharing sessions to equip individuals with the necessary knowledge and skills to drive innovation, product development, and process improvements.
Collaborative research efforts, intellectual property protection, knowledge management systems, skill development initiatives, and ethical considerations characterize knowledge governance in the Dutch semiconductor industry. Knowledge governance is critical to foster innovation, enabling knowledge sharing, and sustaining the industry's competitive advantage in a rapidly evolving technological landscape.

So to answer the question: What are the characteristics of the current mode of governance of the Dutch semiconductor industries? The governance of the Dutch semiconductor industry is characterized by a multifaceted and interconnected approach, encompassing market, hierarchical, network, and knowledge governance.
Market governance drives on competition, innovation, and market-driven dynamics, enabling a balanced and robust industry. Companies like ASML, NXP Semiconductors, and Thermo Fisher Eindhoven contribute to the market governance through their unique products and services, maintaining the industry's competitiveness.
Hierarchical governance is evident within the industry's various organizational structures and extends to research and development activities, manufacturing processes, and regulatory compliance. It enables effective coordination, resource allocation, and the implementation of strategic goals. Externally, the industry is guided by Dutch government policies, initiatives, and EU-level strategies and funding.
Network governance means the power of collaboration and partnerships. Supply chain networks, international collaborations, and regional industry clusters, such as Brainport Eindhoven and ChipTech Twente, form crucial aspects of this governance model. They promote knowledge sharing, innovation, and collective advancement of the industry.
Knowledge governance plays a critical role in managing, sharing, and protecting valuable knowledge and intellectual property within the industry. This includes research collaborations, intellectual property protection, knowledge management systems, skill development initiatives, and ethical considerations.

5.3 Main objectives and policy interventions of the European Chips Act

In February 2023, the EU agreed on the EU Chips Act. The Act will unlock 43 billion euros in investment for Europe's chip sector. It recognizes that semiconductors are the building blocks of modern technologies, encompassing various applications from smartphones and computers to advanced medical equipment and smart cities (European Commission, 2023a; Hoeffnagel, 2023; European Commission, 2023d). The EU Chips Act aims to enhance Europe's autonomy and competitiveness in the semiconductor industry. The Act will build on the current strengths of the industry and create a flourishing ecosystem and, equally important, a resilient supply chain equipped to anticipate and respond to potential future supply chain disruptions. It aims to position the EU as an industrial leader in semiconductors for the long term by advancing European research and technology, bolstering capacity for innovation, solving the skills gap, and improving knowledge of global supply networks (five objectives EU Chips Act) (Lammertink et al., 2023).

5.3.1 Pillars of the Act

The EU Chips Act incorporates three pillars of action to achieve its objectives (European Commission, 2023a; European Commission, 2023d; Inside, 2022; Orgalim, 2022; The European Chips Act, z.d.; Van Wieringen, 2022; Zhang et al., 2023; Inside, 2022). The first pillar, the 'Chips for Europe' initiative, will support large-scale technology capacity building and innovation in cutting-edge chips. This pillar will ''reinforce Europe's technological leadership'' (European Commission, 2023c; Inside, 2022; Zhang et al., 2023). The European Chips Act's second pillar, 'security of supply' will create a framework to ensure supply by luring investments and boosting production capabilities in the semiconductor industry (semiconductor manufacturing facilities, as well as advanced packaging, test, and assembly) via "first-of-a-kind" semiconductor manufacturing facilities, as well as advanced packaging, test, and assembly (European Commission, 2023c; Inside, 2022; Zhang et al., 2023). The European Chips Act's third pillar focuses on measures to ensure the supply of chips during a shortage for European end-customer industries; think of the automotive and the medical sector. The European Chips Act creates a specific toolset of actions that can be used to deal with such circumstances (European Commission, 2023c; Zhang et al., 2023). The pillar establishes a coordination mechanism between the Member States and the Commission to improve cooperation within and among Member States.

5.3.2 Budget distribution

The three pillars aim to drive investments, collaboration, and innovation. The EU plans to mobilise 43 billion, but the financial breakdown remains vague (Vasquez, 2023; Orgalim, 2022; Science Business, 2023). Will fresh money be made available, or is it about reallocating the budget from existing programmes? The European Parliament and the European Committee of the Regions (CoR) state that the Chips Act should receive new budgetary resources; therefore, the Chips Act should be part of the Multiannual Financial Framework (MFF) from 2028 on (European Commission, 2022). All regions in Europe will benefit from this (Sostmann, 2022). Several companies and industry stakeholders welcome the funding, emphasizing its importance for the European semiconductor industry and even stating that 43 billion in funding is far too little (Sostmann, 2022; Vasquez, 2023; Orgalim, 2022). However, the lack of clarity regarding obtaining the funding hinders its effectiveness.

The semiconductor industry needs a high level of upfront capital investment: first mover advantage can be significant. EU policy is focused on research rather than commercialisation: Europe tends to invest much more in science and technology than in further development and commercialisation of this technology (compared to, e.g., North America and Asia) (Johnston & Huggins, 2023).

The EU sets up so-called Chips Joint Undertakings (JU) under Horizon Europe to execute EU research, technological development, and demonstration programmes in public-private partnerships (with multi-partite public EU and national/regional funding and private funding, and no one-on-one financing). "The members of these JUs are typically the European Union (represented by the European Commission) and industry-led associations, as well as other partners. JUs adopt their own research agenda and award funding mainly based on open calls for proposals." (EUR-lex, n.d.). The Chips JU, which replaces the Key Digital Technologies Joint Undertaking (KDT JU), manages and implements the research and innovation programme to reinforce the EU's strategic autonomy in the semiconductor market. The KDT JU undertaking will undergo a strategic reorientation towards Chips JU.

The Chips JU will pool resources (at least 43 billion euros) from the Union, including the Horizon Europe and the Digital Europe Programme , Member States (in total 11 billion euro) and third countries associated with the existing Union programmes, and the private sector (additional 32 billion euros). The proposal complements the Digital Europe programme, which supports digital capacity building in key digital domains where semiconductor technology underpins performance gains, skills development, and the deployment of digital innovation hubs. The proposal supports capacity building to reinforce advanced research, design, production, and systems integration capabilities in cutting-edge and next-generation semiconductor technologies (European Union, 2021; Hoeffnagel, 2023; Van Wieringen, 2022). "The Chips JU also builds on and complements Horizon Europe, which in the area of semiconductors, provides support for academically driven research, technology development, and innovation. The Chips JU will focus on supporting investment into cross-border and openly accessible research, development, and innovation infrastructures set up in the Union to enable the development of semiconductor technologies across Europe. New semiconductor technologies from research and innovation actions supported by Horizon Europe may be progressively taken up and deployed by the capacity-building activities supported by the Chips JU. Conversely, the technology capacities set up under the Chips JU will be made available to the research and innovation community, including for actions supported through Horizon Europe." (European Commission, n.d.)

A Chips Fund will back the Chips JU to promote the inclusion and growth of start-ups, as well as a dedicated equity investment facility under InvestEU to help SMEs expand into new markets (Inside, 2023). This will add to the estimated 43 billion euro of governmental investments in the industry (European Commission, 2023c).

Overall, the goal is to financially 'strengthen existing R&D&I, including the deployment of advanced semiconductor tools, pilot lines for prototyping, testing & experimentation, staff training, and the development of a comprehensive understanding of the semiconductor ecosystem and the EU application value chains relying on it' (Inside, 2023).

5.3.3 The Chips Act's instruments in Bouwma's perspective

The Act aligns with Bouwma's framework (2015) by employing five distinct policy instruments to achieve its goals.

A. Legislative and Regulatory Measures in the Act

Firstly, the Act utilizes legislative and regulatory measures to establish a robust framework for ensuring supply security and bolstering Europe's autonomy in the semiconductor industry (Pillar two 'Security of supply'). This aligns with Bouwma's policy instrument of "Legislation and Regulation" (Bouwma, 2015). The Act includes a Communication, a proposal for a Regulation, and a Recommendation. The Communication explains the European Chips Act strategy and rationale, while the Regulation is the legal act that requires all member states to achieve the goals set in the document without dictating how. The Recommendation sets out a toolbox for monitoring and mitigating chip ecosystem disruptions. All Member States are encouraged to follow the Recommendation. Another example is the new Council Regulation, "amending Regulation (EU) 2021/2085 establishing the Joint Undertakings under Horizon Europe, as regards the **Chips Joint Undertaking**[10]" (European Commission, 2022). This regulation aims to reorientate the existing KDT JU undertaking towards Chips JU to coordinate funding to reach the Act's goals.

B. Economic and Fiscal Instruments: Boosting Investments

Secondly, the Act employs economic and fiscal instruments to drive investments and support the development of the semiconductor industry. This aligns with Bouwma's policy instrument of "Economic Instruments" (Bouwma, 2015). As mentioned, the Act allocates a substantial budget of 43

[10] The bold words in the following chapter (5.3.3) are the instruments following the EU Chips Act.

billion euros, combining public and private investment, to provide subsidies to finance technology leadership in Europe's research, design, and manufacturing facilities. A €2 billion **Chips Fund** will facilitate access to finance for start-ups to propel innovations and attract investors. The additional capital will be attracted through a semiconductor equity investment blending facility under InvestEU to support scale-ups and market expansion by SMEs. The Act also enables the EU to act as a central purchasing body during an eventual semiconductor crisis to secure the supply of crisis-relevant products for critical sectors (EU regulation Chips article 15) (European Commission, 2022). Additionally, the EU will support first-of-a-kind facilities through **fast-track permits**, **prioritized access to pilot lines**, and relative **leniency concerning state aid rules** when offered public support by Member States.

C. Cooperation and Agreement-Based Instruments for Collaboration

The Act also utilizes agreement-based and cooperative instruments to foster collaboration and cooperation among Member States and industry stakeholders. This aligns with Bouwma's policy instrument of "Agreement and Cooperation" (Bouwma, 2015). A coordination mechanism facilitates effective cooperation between the Member States and the European Commission. This mechanism aims to improve coordination, monitor semiconductor supply, predict potential shortages, and activate crisis response measures when required.

Within these response measures, the Act provides a Crisis Response Toolbox. These tools focus on information gathering to monitor semiconductor supply, gauge demand, foresee shortages, and, if necessary, activate a crisis stage. In addition, the Act foresees common purchasing, export authorizations, priority-rated orders[11], and national reserves[12] to secure supply in a crisis. It is expected that the monitoring activities will rely on key intelligence from companies to map weaknesses & bottlenecks in the supply chain and will allow for the assessment & anticipation of future crises and the identification of the required corrective actions (Inside, 2023).

However, Kleinhans and Hess (2022) criticize the Crisis Response Toolbox and point out that the (voluntary) highly granular industry data must be interpreted with caution as analytical resources and expertise are currently lacking. They argue that none of the suggested tools is considered generally effective due to the heterogeneous nature of the semiconductor value chain, which involves diverse and customized products, a high level of specialization in each process step and supplier market, pronounced division of labour, transnational lock-in effects, and lengthy manufacturing cycle times (illustrated in figure 4).

[11] Semiconductor manufacturers that receive subsidies are obliged to prioritise certain orders issued by the EC for critical sectors during a chip shortage.

[12] Not mentioned explicitly in the EU Chips Act but some Member States (such as Spain) plan to establish national reserves ((Catalogue of General State Administration Publications, 2021).

Figure 4

Can the proposed toolbox ensure the security of supply during a chip crisis?

Note: The matrix shows the effectiveness of the proposed crisis response tools across the different levels of the value chain: products, production steps, and inputs. Importantly, there is no box filled with a green circle, as there is no case in which the proposed tools can be considered effective (Kleinhans & Hess, 2022).

The Chips JU is another example of how the EU stimulates cooperation: all proposals must be joint initiatives with parties from different Member States, research institutes, and industries. The EU generally adopted the **Triple Helix** model to engage stakeholders from across society in achieving its goals. Triple Helix partnerships involve academia, business, and (local) government and are very well suited to boost innovation: companies have first access to new technologies, scientists receive feedback from entrepreneurs on the (financial) viability of their solutions, and governments get insight into the types of policy interventions that support innovation. Triple-helix partnerships intend to structurally ensure collaboration for a sector's future development and growth (Reischauer, 2018; Vaivode, 2015).

D. Information and Communication-Based Instruments for Market Assessment

Furthermore, the Act relies on information and communication-based instruments to gather intelligence and assess the state of the semiconductor industry. This aligns with Bouwma's policy instrument of "Information and Communication" (Bouwma, 2015). A good example is the **online platform** to gather information on the market situation to signal potential shortages. By leveraging essential company intelligence, the Act aims to identify weaknesses and bottlenecks within the supply chain, anticipate future crises, and take appropriate corrective actions. Effective information-sharing enhances supply security and enables proactive management of supply chain challenges.

E. Fostering Research and Innovation: Knowledge Instruments

Lastly, knowledge instruments are emphasized within the EU Chips Act to foster research, innovation, and technological leadership in the semiconductor industry. This aligns with Bouwma's policy instrument of "Knowledge" (Bouwma, 2015). The Act supports capacity-building activities such as **pilot lines**, **competence centres**, and resources for quantum chips. Through **investments in R&D** and promoting a deep understanding of the semiconductor ecosystem, the Act aims to drive innovation and maintain Europe's position at the forefront of advanced semiconductor technologies.

In summary, the EU Chips Act effectively utilizes a combination of legislative, economic, cooperative, information-based, and knowledge instruments to strengthen Europe's semiconductor industry, ensure supply security, and drive innovation. By employing these diverse policy instruments, the Act aims to propel the European semiconductor industry forward and position it competitively in the global landscape, while aligning with Bouwma's framework.

To answer the question: What are the European Chips Act's main objectives and policy interventions regarding the semiconductor industry? We can conclude that the European Chips Act's main objectives are to enhance Europe's autonomy and competitiveness in the semiconductor industry, anticipate and respond to potential future supply chain disruptions, advance European research and technology, bolster capacity for innovation, solve the skills gap, and improve knowledge of global supply networks. The Act employs a variety of policy interventions to achieve these objectives, structured around three pillars: (1) the 'Chips for Europe' initiative supports large-scale technology capacity building and innovation in cutting-edge chips to reinforce Europe’s technological leadership. (2) he 'security of supply' pillar creates a framework to ensure supply by attracting investments and boosting production capabilities in the semiconductor industry. It also plans for managing supply during a shortage, particularly for European end-customer industries like automotive and medical sectors. (3) the third pillar establishes a coordination mechanism between the Member States and the Commission to improve cooperation within and among Member States.
In addition, the Act introduces a fund - the Chips Joint Undertakings (JU) - to pool resources and support investment into research, development, and innovation infrastructures. The Chips JU complements the Horizon Europe programme, which supports academically driven research, technology development, and innovation in the field of semiconductors.
The Act also uses Bouwma's policy instruments including legislative and regulatory measures, economic and fiscal instruments, agreement and cooperation, information and communication, and knowledge-based interventions. These interventions aim to foster collaboration, drive investments, support research and innovation, gather market intelligence, and ensure legislative and regulatory framework that bolsters Europe's autonomy in the semiconductor industry.

5.4 Opportunities the European Chips Act provides for the Dutch semiconductor industry

The European Chips Act presents several significant opportunities for the Dutch semiconductor industry to improve its market position and transform its mode of governance. By capitalizing on these opportunities, the industry can strengthen its capabilities, foster innovation, and enhance its competitiveness in the global semiconductor market.
One of the key opportunities lies in the funding and investment provisions of the EU Chips Act. The Act allocates substantial funds for developing and producing semiconductor technologies within the European Union. By leveraging these financial resources, the industry can bolster its capabilities, foster technological advancements, and maintain its competitive edge (S. Nihtianov, May 22, 2023).
Collaboration and research partnerships play a vital role in realizing the potential of the EU Chips Act. The Act encourages Triple Helix collaboration among EU member states, fostering cooperation between Dutch semiconductor companies, universities, research institutions, and their counterparts

in other European countries. Through these collaborative efforts, joint research projects, knowledge sharing, and the exchange of best practices can take place, leading to enhanced innovation, improved capabilities, and increased competitiveness within the Dutch semiconductor industry (K.A.A. Makinwa, May 26, 2023; G.Q. Zhang, May 26, 2023; T. Tiek, May 11, 2023).
Another opportunity presented by the EU Chips Act is the enhancement of supply chain resilience. By strengthening domestic semiconductor manufacturing capabilities within the EU, the Act aims to reduce dependence on external suppliers and mitigate supply chain risks. This is particularly relevant for Dutch semiconductor companies, as they can benefit from a stable and secure supply of critical components and equipment, including those provided by prominent Dutch companies such as ASML, ASMI, NXP, and Besi. The Act's focus on bolstering the semiconductor supply chain can enhance the industry's overall resilience and competitiveness (European Commission 2023a; G.Q., May 26, 2023).
Talent development is another key aspect emphasized by the EU Chips Act: “Europe should address the acute skills shortage, attract new talent and support the emergence of a skilled workforce.” (European Commission, 2022). Recognizing the importance of a highly skilled workforce in the semiconductor industry, the Act aims to support educational programs, vocational training, and research initiatives in the Netherlands (ASML, 2022; Van de Burgt, 2017; IMEC, 2019). Dutch universities, such as the technical universities in Delft, Eindhoven, and Twente, can leverage this opportunity to strengthen the industry's talent pool (K.A.A. Makinwa, May 26, 2023; G.Q. Zhang, May 26, 2023; T. Tiek, May 11, 2023). Efforts to increase the inflow of technical students in secondary vocational, higher professional, and university education should already start at the secondary (and maybe even primary) level.

Lastly, the EU Chips Act acknowledges the significance of emerging semiconductor technologies, including "More than Moore" devices such as sensors, RF components, power electronics, photonics, and quantum computing. By promoting research and development in these areas, the Act opens avenues for Dutch semiconductor companies to innovate and excel in their respective domains. This particularly benefits Dutch companies involved in automotive and RF chip design sectors, such as NXP and Nexperia. By capitalizing on these emerging technologies, the Dutch semiconductor industry can drive technological advancements, diversify its product offerings, and expand its market presence (S. Nihtianov, May 22, 2023).
While the EU Chips Act may face criticisms and challenges, it provides a range of opportunities for the Dutch semiconductor industry to elevate its market position and improve its governance. By leveraging the Act's funding provisions, fostering collaboration and research partnerships, enhancing supply chain resilience, investing in talent development, and capitalizing on emerging semiconductor technologies, the industry can solidify its position as a global leader and contribute to the overall growth and competitiveness of the European semiconductor ecosystem.

To answer the question; What opportunities does the European Chips Act provide for the Dutch semiconductor industry to change its mode of governance and improve its market position? We can conclude the following: the European Chips Act offers several opportunities for the Dutch semiconductor industry to both transform its mode of governance and improve its market position. Key opportunities include access to substantial funding for the development and production of semiconductor technologies, the encouragement of collaborative research and knowledge sharing through Triple Helix collaborations, and the promotion of domestic supply chain resilience to reduce external dependencies. The Act also emphasizes talent development and addresses the need for a skilled workforce in the semiconductor industry, enabling Dutch universities and institutions to nurture talent. Lastly, the Act's focus on emerging semiconductor technologies opens avenues for Dutch companies to innovate and expand their market presence. In summary, by leveraging these opportunities, the Dutch semiconductor industry can strengthen its global standing and contribute significantly to the competitiveness of the European semiconductor ecosystem.

6. CONCLUSION: BEST FITTING MODE OF GOVERNANCE FOR THE DUTCH SEMICONDUCTOR INDUSTRY

The development and growth of the Dutch semiconductor industry are vital for technological innovation and economic progress. The introduction of the EU Chips Act creates new opportunities to improve the industry's market position. Previous chapters analysed the Dutch semiconductor industry and the EU Chips Act. This concluding chapter provides insight into the governance mode that the Dutch semiconductor industry can use to make the most of the opportunities offered by the EU Chips Act.

6.1 Instruments versus SWOT

From Figure 5, we can conclude several insights regarding the recommended strategies and instruments that align with the SWOT analysis of the Dutch semiconductor industry and the objectives of the EU Chips Act. This figure serves as a visual representation of the key elements that can strengthen the industry's market position and leverage the opportunities provided by the EU Chips Act.

Figure 5

Instruments and SWOT objectives for the Dutch industry and government

	Chips Joint Undertaking	Fast-track permits	Chips Fund	Prioritised access to pilot lines	Leniency concerning state aid rules	Triple Helix	Chips Joint Undertaking	Online platform	Pilot lines	Competence centers	Investments in R&D
	A	B				C		D	E		
Strenghts											
Chips Design	++	-	+	+	-	++	++	-	+	+	++
Research collaboration	++	-	-	+	+	++	++	-	+	+	++
Excellent universities	-	-	-	+	-	-	-	-	+	+	-
Highly trained professionals	-	-	-	+	+/-	-	-	-	+	+	-
Strong connection between universities and companies	+	-	-	+	+/-	+	+	-	+	+	+
Excels in certain semiconductor technologies	++	-	+	+	+/-	++	++	-	+	+	++
Supply of equipment for chip manufacturing	+	+	+	+	++	+	+	-	+	+	+
Strong technology position	++	+	+	+	+	++	++	-	+	+	++
Weaknesses											
Absence of semiconductor manufacturing facilities	-	++	+	+/-	+	-	-	-	+/-	+/-	-
Fragmentation of the semiconductor industry	++	-	-	+/-	-	++	++	-	+/-	+/-	++
European funding	++	-	+	+/-	-	++	++	-	+/-	+/-	++
Opportunities											
Specialized semiconductor manufacturing services	-	+	+	-	+	-	-	-	-	+	-
Expand market share in Europe and the United Kingdom	+	+	+	+	++	+	+		+	+	+
Leverage more of the collaborative environment	++	-	-	+	-	++	++	-	+	+	++
Support programs, funding, and resources specifically designed to foster the growth of startups and scale-ups	++	-	+	+	+	++	++	-	+	+	++
Extend target markets	-	-	+	-	+	-	-	-	-	+	-
Threats											
Shortage of qualified (young) people	-	-	-	+	-	-	-	-	+	+	-
Global competition	-	+	-	+	+	-	-	+	+	+	-
Government support	-	-	-	+	n.a.	-	-	-	+	-	-
Fiscal measures	+	-	-	-	+	+	+	-	-	-	+
Alternatives that can compete for market share	-	-	-	-	+	-	-	-	-	-	-
Geopolitical factors	-	+	-	+	+	-	-	+	+	-	-
	20	8	10	15	14	20	20	2	15	15	19

*Note: The Bouwma (2015) instruments are portraited on the horizontal line with A: legislative and regulatory instruments, B: economic and fiscal instruments, C: agreement based and cooperative instruments, D: information and communication- based instruments (see chapter 5.3.3). In de row above that we can see the instruments from the EU Chips Act, categorised in the instruments from Bouwma (**bold words** in chapter 5.3.3). In the first column, the outcome of the SWOT model is portraited. The horizontal plusses and minuses represent whether an instrument is beneficial for that particular strength, weakness, opportunity or threat and is scored on a four-point scale: '++', '+', '+/-', and '-', from ultimately beneficial to not beneficial. For instance, the Chips JU can seriously help strengthen the good position based on chip design (scored '++'). The vertical pluses and minuses show whether it makes sense for the Dutch and EU government to focus on that particular instrument (scored on a four-point scale). The bottom line shows the total number of '+': a high number of total points means that that particular instrument is relatively beneficial for the Dutch industry and that the Dutch government should make sure that instrument is put in place. There are also +/- marks. This means that it is good for the industry, but not for the Dutch government.*

6.1.1 Recommendations industry

The Dutch semiconductor industry can leverage the opportunities provided by the Chips JU to boost R&D and innovation, reinforcing strengths such as chip design and addressing weaknesses like fragmentation (T. Tiek, May 11, 2023). By securing funding through the Chips JU, the industry can enhance its innovation power, knowledge position, and ultimately its market position in Europe and the UK, while also contributing to greater autonomy (T. Tiek, May 11, 2023).

Embracing a triple-helix approach, which fosters collaboration between academia, industry, and government, is crucial for the Dutch semiconductor industry (Huggins et al., 2022). This approach enhances knowledge exchange, research partnerships, and innovation within the sector. Collaborative initiatives encouraged by the EU Chips Act contribute to the development of a stronger European semiconductor ecosystem (Miller, 2022). By leveraging existing clusters and promoting inter-cluster cooperation, the industry can strengthen its position and compete globally (European Commission, 2013; Huggins et al., 2022; Silicon Europe, 2022). Tailored interventions should address cluster-specific shortcomings for optimal results (T. Tiek, May 11, 2023). These strategies align with the industry's growth and competitiveness goals, fostering collaboration and advancing the European semiconductor industry.

Additionally, promoting the establishment of competence centres and pilot lines is recommended. Competence centres act as catalysts for the development of advanced semiconductor technologies, reinforcing industry strengths and addressing challenges such as the shortage of skilled personnel. Pilot lines provide a platform for testing and validating new technologies, thereby enhancing the industry's innovation capacity. Advocating for EU and national support to establish competence centres and pilot lines is crucial for strengthening competitiveness and market position.

Entrepreneurship and valorisation play a vital role in enhancing the market position of the industry. Encouraging spin-offs from universities and fostering collaborations between existing companies and universities promote innovation, create new business opportunities, and stimulate industry growth. The Dutch government should actively support entrepreneurship by providing necessary support and funding to foster entrepreneurial activities and facilitate the valorisation of intellectual property.

6.1.2 Recommendations government

The Dutch government can play a supportive role in strengthening the market position of the semiconductor industry and capitalizing on the opportunities provided by the EU Chips Act. Firstly, the government can support industry participation in the Chips JU by facilitating project proposals. Additionally, creating platforms for knowledge exchange, funding joint research projects, and implementing policies that promote collaboration can further facilitate the triple-helix approach.

Moreover, the government can leverage its influence at the European level to position the Netherlands as an attractive location for establishing competence centres and pilot lines. By highlighting the unique strengths of the Dutch semiconductor industry and advocating for policies that support the establishment of such centres and lines in the Netherlands, the government can enhance the industry's competitive position.

Investing in education and training to ensure an adequate supply of skilled personnel for the semiconductor industry is essential. This can be achieved by funding specialised training programs, offering scholarships to students pursuing careers in the semiconductor industry, and promoting lifelong learning within the sector.

Lastly, the government can support the semiconductor industry in developing a coordinated plan for implementing the recommended strategies. This can be achieved by facilitating strategic planning sessions, providing project management tools and resources, and offering guidance on role assignment and responsibilities within the industry.

With the effective implementation of the recommended governance model and strategies, the Dutch semiconductor industry can significantly improve its market position, strengthen its innovation capabilities, and contribute to the growth and competitiveness of the European semiconductor ecosystem.

6.2 Best mode of governance

Considering the goals of the EU Chips Act and the strengths and weaknesses of the Dutch semiconductor industry, and this report concludes that a network governance, logically within market governance and supported by knowledge governance, is the most appropriate model.

Network governance enables stakeholders, including industry players, research institutions, and governments, to work together in a coordinated manner. It fosters collaboration, knowledge sharing, and joint decision-making, allowing for the pooling of resources and expertise to address common challenges and pursue shared objectives. By leveraging the collective strengths and capabilities of diverse stakeholders, network governance promotes the development of innovative solutions, the establishment of common standards, and the coordination of efforts to enhance the industry's competitiveness.

Network governance, combined with market and knowledge governance, and framed within the hierarchical authority of the Dutch government, allows the industry to leverage resources and expertise collectively. Network governance and market governance run parallel to each other, operating within the legal frameworks of the Netherlands and the EU, considering the inherent tension between competition and collaboration at various levels – EU, global, national, and regional.

Network governance exists where the interests align and where collaboration strengthens the industry's position. By working together, stakeholders can have a greater impact, reach, and influence. The sector focuses on engaging with the government, which in turn interacts with the EU, and ultimately operates at the global level. However, stakeholders also have their own interests that they prioritize.

A network governance model enables stakeholders in the semiconductor industry to collaborate and address their shared challenges while seizing opportunities. It acknowledges the interdependence and interconnectedness of actors within the industry value chain. By pooling resources, knowledge, and efforts, stakeholders can navigate complex regulatory frameworks and technological advancements together. Additionally, knowledge governance creates a system that safeguards intellectual property and proprietary knowledge, which is crucial in the competitive global semiconductor field.

7. LITERATURE LIST

Allen, G. C., & Benson, E. (2023). Clues to the U.S.-Dutch-Japanese Semiconductor Export Controls Deal Are Hiding in Plain Sight. https://www.csis.org/analysis/clues-us-dutch-japanese-semiconductor-export-controls-deal-are-hiding-plain-sight

Alsop, T. (2023, maart). *Semiconductors in the Netherlands - statistics & facts*. statista. https://www.statista.com/topics/7279/semiconductor-companies-in-the-netherlands/#topicOverview

ASML. (n.d.). How microchips are made | ASML. Retrieved June 26, 2023, from https://www.asml.com/en/technology/all-about-microchips/how-microchips-are-made

Aurik, J., Gerdemann, D., Hales, M., Hertel, G., Heinrich, A., & Hubner, D. (2022). *Europes urgent need to invest in a leading edge semiconductor ecosystem*. Kearney. https://www.kearney.com/documents/291362523/291371424/Europes+urgent+need+to+invest+in+a+leading-edge+semiconductor+ecosystem.pdf/f3ec1e30-b8ff-b367-417c-62cf476342ea?t=1636562554000

Balconi M and Fontana R (2011) Entry and innovation: an analysis of the fabless semiconductor business. Small Business Economics 37(1): 87–106.

Baron, C. (2023). *Semiconductors in the Netherlands | Statista*. Statista. https://www.statista.com/study/62604/companies-in-the-semiconductor-industry-in-the-netherlands/

Bish, J., Stewart, D., Ramachandran, K., Lee, P., & Beerlage, S. (2022, November 3). A new dawn for European chips. Deloitte. https://www2.deloitte.com/us/en/insights/industry/technology/semiconductor-chip-shortage-supply-chain.html

Bordoloi, P. (2022). Is ASML the Most Important Tech Company in the World? Analytics India Magazine. https://analyticsindiamag.com/is-asml-the-most-important-tech-company-in-the-world/#:~:text=ASML%20Monopoly,from%20nearly%205000%20different%20suppliers.

Bouwma, I. (2015, 1 december). *Policy instruments and modes of governance in environmental policies of the European Union: past, present and future*. Research@WUR. https://research.wur.nl/en/publications/policy-instruments-and-modes-of-governance-in-environmental-polic

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. Qualitative Research Journal, 9(2), 27–40. https://doi.org/10.3316/qrj0902027

Bown, C. P. (2020, december). *How the United States marched the semiconductor industry into its trade war with China*. PIIE. https://www.piie.com/sites/default/files/documents/wp20-16.pdf

Brainport Eindhoven. (n.d.). Meet high-tech companies and organisations in Brainport Eindhoven. https://brainporteindhoven.com/int/for-you/work/companies

Catalogue of General State Administration Publications. (2021, 4 november). Día Mundial de Lucha contra la Desertificación y la Sequía 17 de junio de 2023. CPAGE. https://cpage.mpr.gob.es/

Ciani, A., Nardo, M., The position of the EU in the semiconductor value chain: evidence on trade, foreign acquisitions, and ownership, European Commission, Ispra, 2022, JRC129035.

EUR-lex. (n.d.). Joint undertakings. https://eur-lex.europa.eu/EN/legal-content/glossary/joint-undertakings.html#:~:text=Article%20187%20of%20the%20Treaty,technological%20development%20and%20demonstration%20programmes.

European Commission (2013) Comparison of European and non-European regional clusters in KETs. The Case of Semiconductors. Final Report: A Study Prepared for the European Commission DG Communications Networks, Content & Technology. Brussels: European Union.

European Commission. (2022, February 8). Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework of measures for strengthening Europe's semiconductor ecosystem (Chips Act). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52022PC0046

European Commission. (2023a, januari 8). *European Chips Act: Communication, Regulation, Joint Undertaking and Recommendation*. Retrieved May 4 2023, from https://digital-strategy.ec.europa.eu/en/library/european-chips-act-communication-regulation-joint-undertaking-and-recommendation

European Commission. (2023b, July 4). Alliance on Processors and Semiconductor technologies. Retrieved June 24, 2023, from https://digital-strategy.ec.europa.eu/en/policies/alliance-processors-and-semiconductor-technologies

European Commission. (2023c, april 18). *Press corner*. European Commission - European Commission. Retrieved May 4 2023, from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_2045

European Commission. (2023d, June 15). European Chips Act: Shaping Europe's digital future. https://digital-strategy.ec.europa.eu/en/policies/european-chips-act#:~:text=The%20Chips%20Act%20proposes%20a,the%20first%20of%20their%20kind.

European Commission. (z.d.). Procedure 2022/0033/NLE. EUR-Lex. Geraadpleegd op 20 juni 2023, van https://eur-lex.europa.eu/procedure/EN/2022_33

European Union. (2021). *Key Digital Technologies Joint Undertaking | European Union*. https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/search-all-eu-institutions-and-bodies/key-digital-technologies-joint-undertaking_en#:~:text=Overview,electronic%20components%20and%20systems%20sector.

European Union. (2021a, 29 april). REGULATION (EU) 2021/694 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0694

European Union. (n.d.). About InvestEU. InvestEU. https://investeu.europa.eu/about-investeu

Europees Parlement akkoord met twee wetsvoorstellen rondom European Chips Act | Executive People. (z.d.). https://executive-people.nl/715188/europees-parlement-akkoord-met-twee-wetsvoorstellen-rondom-european-chips-act.html

FD. (2017, November 27). *Tekort technisch personeel dwingt zelfs ASML tot nadenken over bokkensprongen*. FD.nl. https://fd.nl/ondernemen/1229364/tekort-technisch-personeel-dwingt-zelfs-asml-tot-nadenken-over-bokkensprongen

Hayes, A. (2023). Venture Capital: What Is VC and How Does It Work? Investopedia. https://www.investopedia.com/terms/v/venturecapital.asp#:~:text=Venture%20capital%20is%20a%20term,%2C%20and%2For%20managerial%20experience.

High Tech NL. (n.d.). *Value chain | High Tech NL*. Retrieved April 2, 2023, from https://www.hightechnl.nl/semiconductors/value-chain/

Hoeffnagel, W. H. (2023, March 28). Europees Parlement akkoord met twee wetsvoorstellen rondom European. . .. Dutch IT Channel. Retrieved June 20, 2023, from https://www.dutchitleaders.nl/news/221405/europees-parlement-akkoord-met-twee-wetsvoorstellen-rondom-european-chips-act

Holland High Tech. (2019). The whole Semicon value chain is in one country. High tech NL. Retrieved March 4th, 2023, from https://www.hightechnl.nl/wp-content/uploads/2019/11/Company-profiles-Semicon-Europa_2019.pdf

Holland Semiconductors. (n.d.). National network of semiconductor companies - Holland Semiconductors. Retrieved May 15, 2023, from https://hollandsemiconductors.nl/.

Hollandhightech. (2018). *Roadmap Semiconductor Equipment. Innovation Agenda 2018 - 2021*. https://hollandhightech.nl/en/how-we-help/agenda-htsm

Huggins, R., Johnston, A., Munday, M., & Xu, C. (2022). The Future of Europe's Semiconductor Industry: Innovation, Clusters and Deep Tech. In *CS Connected*. https://csconnected.com/media/ezlhpdhz/huggins-johnston-munday-xu-the-future-of-europes-semiconductor-industry.pdf

IMEC. (2019, November 19). *SEMI, partners launch largest microelectronics education initiative co-funded by Erasmus+ program*. https://www.imec-int.com/en/articles/semi-partners-launch-largest-microelectronics-education-initiative-co-funded-by-erasmus-program

Inside. (2022, May 18). *The Chips Act: three pillars for semiconductor security*. Inside. https://www.inside-association.eu/post/the-chips-act-three-pillars-for-semiconductor-security

Kleinhans, J.-P., & Hess, J. (2022, September 1). Governments' role in the global semiconductor value chain #3. Stiftung Neue Verantwortung (SNV). https://www.stiftung-nv.de/en/publication/eca-toolbox#_ftn15

KPMG. (2020, October). *SWOT-analyse strategische waardeketens*. Ministerie Van Economische Zaken En Klimaat. https://open.overheid.nl/repository/ronl-b2ad5fa4-306b-41aa-869f-a82ac41911ee/1/pdf/bijlage-swot-analyse-strategische-waardeketens.pdf

Kregting, A. (2021, March 5). Semiconductor Packaging Archives - Lifeport. Lifeport. Retrieved June 4, 2023, from https://lifeport.nl/nieuws/tag/semiconductor-packaging/

Lammertink, J., De Feijter, T., Giri, C., Gomes, A. F., Okano-Heijmans, M., & Hofstede, S. (2023, February). *Dutch semiconductor interests in Asia*. Leidenasiacentre. https://leidenasiacentre.nl/wp-content/uploads/2023/02/Dutch-semiconductor-interests-in-Asia.pdf

Leiden Asia Centre. (n.d.). Map of the Asian semiconductor industry and its connections with the Netherlands. Retrieved May 13, 2023, from https://leidenasiacentre.nl/map-of-dutch-semiconductor-interests-in-asia/

Lima, C. F., Bastos, R. P., & Varvakis, G. (2022). *KNOWLEDGE SHARING THROUGH RESEARCH COLLABORATIVE NETWORKS*. https://doi.org/10.48090/ciki.v1i1.1143

Makinwa, K.A.A (2023, May 26) Personal communication (in-person interview)

Melvin, C. (2023, 20 maart). EU Chips Act: Realizing Europe's Ambition by 2030: Part 1. SEMI. https://www.semi.org/en/blogs/technology-and-trends/eu-chips-act-realizing-europe-ambition-by-2030-part-1

Meuleman, L. (2010) The Cultural Dimension of Metagovernance: Why Governance Doctrines May Fail, Public Organization Review 10, 49–70.

Miller, C. (2022, September 29). The EU's Confused Role in the "Chip War." AEI. Retrieved June 6, 2023, from https://www.aei.org/articles/the-eus-confused-role-in-the-chip-war/

Ministerie van Economische Zaken en Klimaat. (2021, November 24). *SWOT-analyse strategische waardeketens*. Rapport | Rijksoverheid.nl. https://www.rijksoverheid.nl/documenten/rapporten/2020/10/30/swot-analyse-strategische-waardeketens

Nambisan S., Wright H. and Feldman M. (2019) 'The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes', Research Policy, 48: 103773.

Nathan Associates Inc. (2016). BEYOND BORDERS: THE GLOBAL SEMICONDUCTOR VALUE CHAIN. Semiconductor Industry Association. https://www.semiconductors.org/wp-content/uploads/2018/06/SIA-Beyond-Borders-Report-FINAL-June-7.pdf

Nellis, A. a. T. S. S. (2020, January 6). Trump administration pressed Dutch hard to cancel China chip-equipment sale: sources. U.S. https://www.reuters.com/article/us-asml-holding-usa-china-insight-idUSKBN1Z50HN

Nihtianov, S. (2023, May 22) Personal communication (online interview)

NXP. (2022, December). *Annual Report for the fiscal year ended December 31, 2022*. https://www.nxp.com/docs/en/supporting-information/2022-IFRS-SAR.pdf

NXP. (2023, January). NXP SEMICONDUCTORS CORPORATE OVERVIEW. NXP.com. https://www.nxp.com/docs/en/supporting-information/NXP-CORPORATE-OVERVIEW.pdf

OECD (2019), "Measuring distortions in international markets: The semiconductor value chain", *OECD Trade Policy Papers*, No. 234, OECD Publishing, Paris, https://doi.org/10.1787/8fe4491d-en.

Orgalim. (2022, September 9). *Digital Transformation: Orgalim position on the Chips Act proposal*. https://orgalim.eu/position-papers/digital-transformation-orgalim-position-chips-act-proposal

Porter, M. E. (1980). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1496175

Porter, M. E. (2023, February 7). The Competitive Advantage of Nations. Harvard Business Review. https://hbr.org/1990/03/the-competitive-advantage-of-nations

Raider, H. J. (1998). Market Structure and Innovation. Social Science Research. https://doi.org/10.1006/ssre.1997.0608

Reg Brennenraedts et al., "Het Nederlandse investeringsklimaat", https://www.dialogic.nl/wp-content/uploads/2021/06/Dialogic2020.170-MinEZK-Het-Nederlandse-investeringsklimaat.pdf.

Reischauer G (2018) Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing. Technological Forecasting and Social Change 132(1): 26–33.

Research.com. (2023, 17 maart). *How to Write a Research Question: Types, Steps, and Examples*. https://research.com/research/how-to-write-a-research-question#types

Riccucci N. M. (2010). *Public administration: Traditions of inquiry and philosophies of knowledge*. Washington, DC: Georgetown University Press.

Rijksoverheid. (n.d.). *Kennis- en Innovatieagenda HTSM*. Wageningen University & Research. Retrieved June 5, 2023, from https://edepot.wur.nl/359100

Romme AGL (2022) Against all odds: how Eindhoven emerged as a Deeptech ecosystem. Systems 10(4): 119..

Schooley, S. (2023, 21 februari). *SWOT Analysis: What It Is and When to Use It*. Business News Daily. https://www.businessnewsdaily.com/4245-swot-analysis.html

Semi-Literate. (2021, 3 mei). From TSMC to Tungsten: Semiconductor Supply Chain Risks. *Semi-Literate*. https://semiliterate.substack.com/p/from-tsmc-to-tungsten-semiconductor

SIA (2022) Semiconductor Industry Association 2022 Factbook. https://www.semiconductors.org/wp-content/uploads/2022/05/SIA-2022Factbook_May-2022.pdf

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Social Business (2023).Act three: Chips Act heads into negotiation phase. https://sciencebusiness.net/news/ICT/act-three-chips-act-heads-negotiation-phase

Sostmann, T. (2022, October 12). *Chips Act: local leaders demand adequate funding to expand semiconductors*. European Committee of the Regions. https://cor.europa.eu/en/news/Pages/Chips-Act-funding.aspx

Stam, E., Romme, A. G. L., Roso, M., van den Toren, J. P., & van der Starre, B. T. (2016). The Knowledge Triangle in the Netherlands. OECD. https://stip.oecd.org/assets/TKKT/CaseStudies/32.pdf

Statistics Netherlands (2020) Domestic R&D Expenditure over €18 Billion in 2020. https://www.cbs.nl/en-gb/news/2022/05/domestic-r-d-expenditure-over-18-billion-in-2020

The European Chips Act. (z.d.). https://www.european-chips-act.com/

The White House. (2023). FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

Tiek, T. (2023, May 11) Personal communication (in-person interview)

Tweede Kamer der Staten-Generaal. (2020, June 25). *Visie op de toekomst van de industrie in Nederland*. Tweede Kamer Der Staten-Generaal. https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2020Z20167&did=2020D43344

Vaivode, I. (2015). Triple Helix Model of University–Industry–Government Cooperation in the Context of Uncertainties. Procedia - Social and Behavioral Sciences, 213, 1063–1067. https://doi.org/10.1016/j.sbspro.2015.11.526

Van de Burgt, D. (2017, April 13). *Topsector pakt schaarste technici aan*. Bits&Chips. https://bits-chips.nl/artikel/topsector-pakt-schaarste-technici-aan/

Van Gerven, P. (2022, March 31). Europe's glorious semiconductor past doesn't exist. Bits & Chips. https://bits-chips.nl/artikel/europes-glorious-semiconductor-past-doesnt-exist/

Van Heffen, O., & Klok, P. (2000). Institutionalism: State Models and Policy Processes. In Library of public policy and public administration. Springer Nature (Netherlands). https://doi.org/10.1007/978-94-015-9486-8_8

Van Wieringen, K. (2022, July 7). *Strengthening EU chip capabilities: How will the chips act reinforce Europe's semiconductor sector by 2030? | Think Tank | European Parliament*. Think Thank European Parliament. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733585

Vasquez, M. (2023, January 9). *EU Chips Act, the debate goes on- Geopolitics: remaining open for business*. Aeneas. https://aeneas-office.org/2023/01/06/eu-chips-act-the-debate-goes-on-geopolitics-remaining-open-for-business/

VEB, (2020). ASML's technologische voorsprong moet zich nu uitbetalen. Retrieved from https://www.veb.net/artikel/07415/asmls-technologische-voorsprong-moet-zich-nu-uitbetalen#:~:text=VEB%20%2D%20ASML's%20technologische%20voorsprong%20moet%20zich%20nu%20uitbetalen&text=Technisch%20vernuft%2C%20massa's%20kapitaal%2C%20geduld,astronomische%20succes%20van%20ASML%20verklaren.

Wipo. (2022). Global Innovation Index 2022, 15th Edition. *www.wipo.int*. https://doi.org/10.34667/tind.46596

Witteman, J. (2023, June 9). Koning van de kunstmatige intelligentie. *Volkskrant*, 27.

Zhang, G. Q., Benschop, J. P. H., Blickman, R., Van Den Berg, A., Nauta, B., Baltus, P. G. M., & Jacobs, W. G. (2023, February 7). *Report towards an NL Chip Plan – Establishing a stronger NL Chip sector*. AcTi. https://www.acti-nl.org/report-towards-an-nl-chip-plan/

Zhang, G.Q. (2023, May 26) Personal communication (in-person interview)

8. APPENDIX

8.1 Appendix A: coding scheme

Theory (if applicable)	Topic	code
	Chip Usage & Demand	
		Chip Applications
		Chip Demand
		Chip Description
	Industry Basics	
		Knowledge intensive
		High capital intensity
		Moore's Law
		Geopolitical tensions surrounding semiconductors
		Economic importance
		Global supply chain and its susceptibility to disruptions
		Importance of research and development
		Dominance of large players
		Definition of "chip" and "semiconductor"
		Integrated circuits (ICs)
		Semiconductor materials
		Silicon (Si)
	Semiconductor Value Chain	
		Semiconductor value chain stages
		Research and Development (R&D)
		Design phase
		Manufacturing phase
		Packaging, Assembling, and Testing phase
		Distribution of chips
		Complexity and competitiveness of each production stage
		Amount of companies in the world
		Dutch complete semiconductor industry value chain
		Chip design and architecture specialization
		Global and European market comparison
	Market Analysis	
		Revenue generation
		Investment
		Global innovation index ranking
		Global suppliers and contractors
		Market drivers (e.g., IoT, AI, Quantum computing, 5G and 6G, AR/VR, automotive industry)

Theory (if applicable)	Topic	code
	Market Drivers	
		EU trade and relations in the semiconductor industry
		Importance of semiconductors in global economies
		US Semiconductor Strategy
		China Semiconductor Strategy
		South Korea Semiconductor Strategy
		Covid -19 and chip shortage
	Dutch Semiconductor Industry	
		High Tech Systems and Materials (HTSM) sector
		Key Dutch semiconductor companies
		Dutch semiconductor cluster
		Dutch semiconductor sector employment
		Dutch innovation capacity
		Dutch semiconductor industry global relevance
		Collaboration with universities and knowledge organizations
		Venture capital investment growth
	Stakeholders	
		Stakeholders in the Dutch semiconductor industry
		Investors, venture capitalists, and financial institutions
		Customers and end-users
		Major Dutch semiconductor companies (ASML, ASM International, BE Semiconductor Industries (Besi) and NXP)
		Industry associations (Holland Semiconductors and PhotonDelta)
		Research groups at Dutch universities
		Government stakeholders (e.g., Rijksdienst voor Ondernemend Nederland (RVO), Netherlands Foreign Investment Agency (NFIA))
	R&D and Government Initiatives	
		Government budget for R&D
		Importance R&D
		Important Project of Common European Interest (IPCEI)

Theory (if applicable)	Topic	code
SWOT	Strenghts	
		Chip design
		Equipment manufacturing
		packaging
		Hetrogeneous integration
		More than moore devices
		Design for X
		quantum computing
		collaboration between stakeholders
		Scientific level
		Education and research
		Collaborations and Partnership
		Technical expertese and Innovation
		Regional and National strategy
	Weaknesses	
		Manufactor facilities
		Collaboration and coordination
		Funding and influence
		Strategy and growth
	Opportunities	
		Advanced manufacturing capabilities
		Geographical advantage
		Collaboration and innovation
		Government and private support
		Metrology
		Autonomous driving
		Photonic chips
		Quantum technology
	Threats	
		Shortage of talent
		Global competition
		Government support
		Fiscal measures
		Alternatives that can compete for matket share
		Geopolitical factors
Porter		
		Scaricity of skillet talet
		Large customers
		Competing with low prices
		Substitute products or services
		Threat of substitutes

Theory (if applicable)	Topic	code
Bouwma and Van Heffen and Klok	Market governance	
		Open market
		Market-driven framework
		Competition between companies
		Innovation
	Hierarchical governance	
		Hierarchical organisational structures
		Descision-making authority
		R&D domain
		Manufacturing processess
		Regulatory compliance
		Industry associations
		Dutch government policies
		EU level
	Network governance	
		Absence of Formal Governance Structure
		Domestic Networking Among Industry Stakeholders
		International Collaborations and Partnerships
		Regional Semiconductor Clusters
		Industry Associations
		Roles of Clusters and Associations
		Collaboration beweeen individuals and organisations
		Research Collaboration and Knowledge Sharing
	Knowledge governance	
		Knowledge Management Systems and Processes
		Training and Skill Development Initiatives
		Joint Research Projects and Partnerships
	EU Chips Act Overview	
		Aim to Enhance Europe's Autonomy and Competitiveness in the Semiconductor Industry
		Investment for Europe's Chip Sector
		Short-term and Long-term Objectives
		Five Strategic Objectives of the Act
		Targeted Emerging Technologies
		Key Digital Technologies Joint Undertaking
	Three Pillars of the EU Chips Act	Chips for Europe
		Security of Supply

Theory (if applicable)	Topic	code
		Coordination Mechanism
	Budget Distribution and Challenges	
		Uncertainty in Budget Distribution
		Need for Concrete Actions by Member States
		Process of Accessing Funding is Unclear
		Importance of Funding for the Industry
		General
Bouwma's Framework, 2015	Policy Instruments Employed by the EU Chips Act	
		Legislative and Regulatory Measures
		Economic and Fiscal Instruments
		Agreement-based and Cooperative Instruments
		Information and Communication-based Instruments
		Knowledge Instruments
	Impact and Goals of the EU Chips Act	
		Driving Investments, Collaboration, and Innovation in the Semiconductor Industry
		Ensuring Supply Security and Bolstering Europe's Autonomy
		Fostering Research, Innovation, and Technological Leadership
		Anticipating and Managing Supply Chain Challenges
		Positioning Europe Competitively in the Global Semiconductor Industry.

UNIVERSITY OF TWENTE
Drienerlolaan 5
7522 NB Enschede

P.O.Box 217
7500 AE Enschede

P +31 (0)53 489 9111

info@utwente.nl
www.utwente.nl

UNIVERSITY OF TWENTE.