The Netherlands and South Korea: From Semiconductors to Universities

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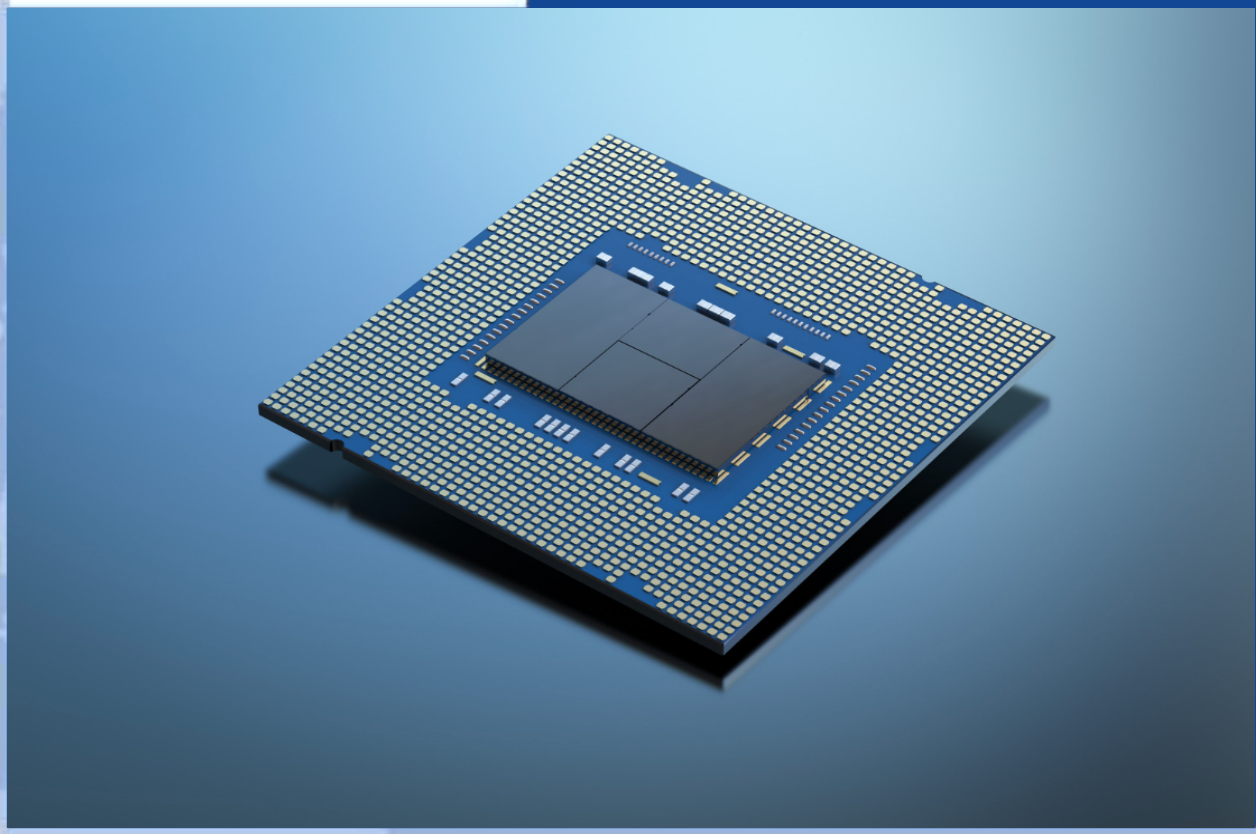

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Recommendations

This report explores the semiconductor industry in South Korea and the Netherlands in a global context and offers recommendations for furthering collaboration. In short, these recommendations are the following:

1. The Netherlands' and South Korea's semiconductor companies are mostly complementary and should collaborate in strengthening and developing their respective positions in the industry.
2. South Korea has expressed its willingness to deepen ties with the Netherlands bilaterally, including through education and scientific collaboration. As such, stakeholders in both countries should invest in the collaborative development of human resources, as the semiconductor industry is facing increasing shortages of workers.
3. The Netherlands has remained strong in attracting and retaining foreign talent, while South Korea aims to do the same. However, the Netherlands' political climate has grown increasingly hostile to international students and workers, creating an unstable environment for semiconductor companies. The Dutch government should refrain from removing incentives for attracting foreign talent (such as removing tax credits) and refocus its efforts on investing in attracting skilled international workers to replenish a dwindling work force.
4. The Netherlands should focus on strengthening key technologies, rather than becoming swept up in the EU's ambition to reshore semiconductor production, which runs counter to South Korean ambitions in the semiconductor industry. Although some of the EU's policy propositions could be beneficial to the Dutch semiconductor industry, such as investing in competence centres, the Dutch government should chart its own course and refrain from becoming a significant competitor of South Korea in key areas of the semiconductor supply chain.

Executive summary

Recent years have seen increasing economic and technological separation between the United States and China, often referred to as 'decoupling'. In a bid to restrict China's access to sensitive technology, the United States recently introduced new export controls for semiconductor technology. It is anticipated that current US measures will persist and potentially strengthen in pursuit of the US government's 'small yard, high fence' approach.

The US is exerting pressure on the Dutch government to comply with these rules, thus posing a challenge for the Netherlands because of its substantial economic ties with China. In 2022 alone, the Netherlands traded over 64 billion EUR worth of goods with China, of which the export of semiconductor equipment accounted for 22.4 billion EUR.

For example, the Netherlands implemented export controls on ASML machines for 'national security' reasons, partly because of pressure from the US. Export licences are now required for certain models of chip-making equipment. The Dutch government can now stop exports to 'specific countries'. It is clear that China was the main target of these measures, despite not being named directly. However, at the time of writing, these measures have had limited impact.

South Korean chip firms have also been caught in the fray. Similar to the Netherlands, South Korea's heavy reliance on China as its largest trading partner has made it increasingly difficult to balance its interests.

South Korea is now actively trying to reduce these dependencies, as evidenced by a significant trade deficit with China in 2023 and an increase in exports to the US. This shift in trade destinations is accompanied by a strengthening of security relations with the US, while China has shown itself willing to coerce South Korea economically into following its agenda. This coercion, however, has led South Korean firms to show increased willingness to invest in the US, despite the higher costs involved.

In addition, South Korea's semiconductor industry is receiving extensive government support and investments to enhance its global position. For example, the South Korean government has promised tax credits for research and development (R&D) spending and

facility investments, alongside a significant investment fund aimed at incentivizing private investments of over 453 billion USD by 2030, and has provided infrastructure support to companies for expansion.

However, as subsidies and tax incentive programmes spread, national security rose up the political agenda. South Korea's government, for example, passed the Special Measures Act on Strengthening and Protecting Competitiveness of National High-Tech Strategic Industry (the National High-Tech Strategic Industry Act) on 3 February 2022. This law provides tax deductions and expedites the bureaucratic processes necessary for manufacturing advanced technologies, but also places companies under further government regulations if they manufacture 'National High Technologies' that are important to national security.

The Dutch government has also implemented policies to support the semiconductor industry, focusing on incentivizing investment in R&D, promoting public–private partnerships, human resource development, and providing a regulatory framework that encourages companies to stay or settle in the Netherlands. According to the Dutch government's recently formulated National Technology Strategy, semiconductors are a critical sector, leading to focused implementation of these policies in this industry. Similar to in South Korea, semiconductors are now also considered vital for national security and public interest, making them subject to additional security measures.

Recent policy shifts have, however, prompted semiconductor companies to express concerns about the Dutch government's political direction. The government's decision to reduce the budget for tax credits for foreign skilled workers has raised concerns about deterring foreign talent and impacting innovation in the Netherlands. Additionally, political discourse on the internationalization of higher education and protecting the Dutch language has created uncertainties about the Netherlands' potential to continue to attract foreign students. This shift is particularly worrying for companies like ASML, where a substantial portion of employees are of foreign origin.

Similarly, South Korea faces a chronic shortage of workers in the semiconductor industry. In a bid to alleviate this shortage with foreign talent, South Korea has announced that it aims to attract 300,000 foreign students by 2027. In fact, in 2023 it enrolled 182,000

foreign exchange students. Although this fell short of the government's target of 200,000 for 2023, it still represents a significant increase from the approximately 12,000 international students in 2001. This growth indicates success in internationalizing South Korea's higher education institutions.

In a broader context, and with global worker shortages in the semiconductor industry, the European Union is attempting to cultivate more talent as well. The EU Chips Act, enacted in 2023, aims to enhance Europe's independence in chip and semiconductor technology. It involves funding for R&D, investments in new chip-production capacities and monitoring markets to predict supply shortages, but it also aims to establish 'competence centres' to attract and educate more talent for the industry.

Despite its success until recently in attracting foreign talent and international students studying technical or information technology-based (IT) career paths, the Netherlands is currently struggling with personnel shortages, particularly in the semiconductor industry. The EU's strategy, although falling short in certain areas, connects well with the Netherlands' goal of alleviating these shortages. However, critics have raised concerns about the EU Chip Act's structure, funding, strategic orientation and governance framework, especially the EU's attempt at 'reshoring' the production of semiconductors.

As the Netherlands' semiconductor companies have focused on specific sectors of the industry, reshoring the complete supply chain would mean direct competition with South Korea. Following the EU's policy, therefore, would undermine the Netherlands' opportunities for deepening ties with South Korea.

It is important to note that South Korea and the Netherlands have complementary roles in the semiconductor industry. They compete globally for market share and revenue, but have agreed to enhance collaboration at an industrial alliance level. Additionally, South Korea has expressed its willingness to deepen collaboration with the EU on advanced semiconductor technologies. The EU's reshoring strategy, and investing in direct competition with South Korean companies, would be detrimental to long-term cooperation.

Education and personnel development are therefore crucial, as they are an area in which improved bilateral relations could help in diverting investments away from increasing competition between the Netherlands and South Korea, while simultaneously alleviating the increasing worker shortages in both countries.

Bilaterally, both the Netherlands and South Korea are heavily invested in improving their position in the semiconductor industry, indicating an alignment in political goals as well as their complementary roles in the industry. Moreover, both countries have attempted to shift away from China-based dependencies, once again showing political alignment in terms of both economic and national security goals. Both countries are, therefore, in an excellent position to deepen their ties and promote cooperation.

However, the current political climate in the Netherlands poses a significant risk. Increasing hostility towards 'internationalization' in higher education and removing incentives for skilled foreign talent form risks for semiconductor companies based in the Netherlands, which rely heavily on this pool of workers for their operations. It seems that current political actors in the Netherlands are overlooking the long-term risks associated with isolating Dutch higher education from international talent, thereby destabilizing the supply of skilled workers to the domestic semiconductor industry.

Author's note

On 6 June 2024 the Leiden Asia Centre held an event to present the completion of this report. Academics, policymakers, and experts gathered to discuss the findings (under Chatham House rules, to allow for a free and open discussion) and provide their take on the recommendations and the conclusions presented here. Several comments stood out.

Firstly, it must be emphasized that policies regarding semiconductors, both as a technology and an industry, are never made in a vacuum. In the case of The Netherlands, the European Union plays a major role in the limitations the Dutch government has with regard to formulating its own position. Cooperation between countries within the EU can be difficult, especially when it concerns diverging interests between member states, or in which inter-European competition within specific industries also plays a role. In South Korea, the larger context consists of trade conflicts and dependencies with companies and governments from countries and regions such as Japan, China, Taiwan, Singapore, and Malaysia. Some of these can be fraught with political sensitivities that reach far beyond the semiconductor industry, and the scope of this report. The reader would, therefore, do well to delve into these contexts in order to better understand the conclusions and recommendations that this report has made.

Secondly, the objectives of the industry players and the governments involved in the complex interplay between public and private can be difficult to follow and understand for those who are not willing to dedicate time and effort into following recent developments. Because of the complexity of the technology, delving into the topic might present with initial hesitation and outright refusal to dedicate time and attention to a topic that, in reality, has in incalculable impact on our personal lives. Creating a better understanding, and willingness to engage with the topic of semiconductors, would benefit the general public. This is, however, a duty of those in the media, government, and industry: to generate interest in semiconductors, a technology that forms the foundation of our modern societies.

To conclude: the discussion on 6 June proved to all of those present that there are few limits to the technology, as well as to the consequences of the politics and policies concerning semiconductors, more popularly known as chips. With the coming-of-age of artificial intelligence (a term that is still vague and hotly debated, but nevertheless increasingly

important), the growing complexity of internet-based systems, digital businesses and institutions, digital currencies, and advanced military materials, the semiconductor will become all the more important. It will do the reader good, as our discussants concluded, to realize this particular point: there is no going back on inventing new technologies, but the future is full of considerations about how we will use them.

The author would like to thank Leiden Asia Centre for their continued support of the project, despite initial setbacks. Thank you, in particular, to Florian Schneider, Floris Harm and Marloes Smeets for their valuable comments and feedback. I am not a South Korea specialist, and the content of this report was by and large dictated by interviews with industry specialists, policy makers, company representatives, journalists, academics, and experts. These took place in South Korea over the past year. For this I want to thank all those who made time, and took the effort, to explain the complexities and intricacies of the industry.

Lastly, and importantly, the author has no conflicts of interests.

US–China decoupling and the semiconductor industry

The term 'decoupling' has been commonly used in recent years to describe the growing tension and increasing economic and technological separation between the United States and China. This section provides a brief description of this development in the context of the semiconductor industry.

This development has been described in many ways. While the US calls it 'strategic competition' (Sutter, 2024), the World Trade Organization has simply dubbed it a 'conflict' (Bekkers and Schroeter, 2020). China has been straightforward in calling the US a 'unilateral bully', accusing the country of 'illegal retaliatory measures' (Farge, 2023).

Outside the political reprisals, the term 'decoupling' has taken hold in academic circles to define how, over the last decade, both the US and China have imposed tariffs on each other's imports in an effort to address trade imbalances and protect domestic industries, leading to disruptions in global supply chains and a deterioration of economic ties between the two countries (Wyne, 2020). For practical purposes, this report also uses the term 'decoupling'.

Regardless of the terminology, this development has had substantial effects on the semiconductor industry, with the United States aggressively asserting its dominant position in the industry (Calhoun, 2021) through trade restrictions against China, specifically concerning cutting-edge technological research and the most advanced chips currently available (Ting-Fang, 2023a).

This protectionist move is the result of growing geopolitical tensions with China about trade, national security concerns and intellectual property disputes.[1] These, in turn, have put pressure on the complex supply chains that form the basis of the industry.

For the Netherlands, this has played out in the form of pressure from Washington to limit sales of equipment to China. On 7 October 2022, the United States introduced a set of

[1] See, for example, the official complaint from China concerning trade restrictions on semiconductors and semiconductor equipment at the World Trade Organization (WTO, 2022).

new export controls for semiconductor technology in a bid to limit China's access to sensitive technology (Bureau of Industry and Security, 2023).

One year later in 2023, the Bureau of Industry and Security (BIS) released an updated set of rules that: 1) made the 'performance density' of semiconductors the principle by which the US government can now limit the export of chips (in simpler terms: allowing a broader ban on new chips, including those produced specifically for the Chinese market and designed to avoid the export controls already in place); 2) widened the geographic scope of export restrictions to countries that would be more likely to transfer shipments of both chips and production equipment from the United States to China without prior clearance from US authorities (for example, an export license); and 3) added thirteen more firms that have been blacklisted from receiving the aforementioned technologies (Benson, 2023).

The extensive update of the original export controls exceeded those already put in place by the Dutch government in earlier policy shifts towards limiting the transfer of sensitive technology, including semiconductor technology, to non-preferred countries. Moreover, it is likely that current US measures will not be rolled back for the foreseeable future, and will actually be strengthened over the coming years, in pursuit of what the US calls a 'small yard, high fence' approach (Siripurapa and Berman, 2023).

The United States is now clearly pressuring the Dutch government to go along with these rules. This is a difficult situation for the Netherlands, which has strong economic ties with China, trading over 64 billion EUR worth of goods in 2022 alone, a number that has doubled in less than seven years, since 2015 (CBS, 2023).

Importantly, the export of semiconductor equipment to China accounted for 22.4 billion EUR worth of exports in the same year, 2022 (CBS, 2023). As a consequence, the semiconductor industry, and most notably the Dutch equipment producer ASML, has become a staple for the Dutch economy and an important asset in political negotiations (Kasteleijn, 2023b). In fact, outgoing Dutch Prime Minister Mark Rutte travelled to China in an attempt to reassure Chinese President Xi Jinping that the implemented export controls would not affect the Chinese ability to keep producing chips (NOS, 2024a), although very few stakeholders seemed convinced (Woo and Cao, 2024).

Nevertheless, for the time being, ASML has not been significantly affected by current controls, as its limited production capacity has resulted in a years-long backlog of orders, and the export controls only affect the most advanced equipment that the company produces (Kasteleijn, 2023a). In fact, the company has scaled up its equipment exports to China, despite the measures in place (Kasteleijn, 2024).

Moreover, chip companies with foundries outside of China are now openly vying for preference for new machines, making it unlikely that ASML will run into order issues in the near future (Sohn and Fitch, 2023).

This does not mean that ASML is in the clear. The company relies heavily on US technology and patents in its production of semiconductor equipment. Suppliers throughout its value chain, including companies that it owns (such as extreme ultraviolet (EUV) light equipment producer Cymer), are based in the United States, making the company vulnerable to future measures (Ting-Fang, 2023a).

Dutch companies are also invested in strengthening their activities in the United States, with Dutch company ASM International, for example, announcing it will invest 300 million EUR in new US-based business activities. ASML has also indicated plans to open education facilities in Arizona, where the United States is trying to build a hub for semiconductor production (Bronkhorst, 2023).

South Korean chip firms are similarly stuck between vying superpowers China and the US, with the added stress of periodic trade skirmishes with. Japan over crucial raw materials. Lammertink *et al.* (2023) provide a detailed explanation of this particular predicament in their case study on Dutch semiconductor interests in Asia (Lammertink *et al.*, 2023). For clarity, this report will only briefly cover the main issues concerning South Korea's position with regard to US–China decoupling, and in the context of recent developments in the semiconductor industry.

South Korea has mostly been successful in balancing its interests between the US and China. Nevertheless, this has become increasingly difficult to achieve, as South Korea is still heavily reliant on China, which is its largest trading partner (World Bank, 2024).

South Korea imports most of its raw materials from China, including those used in semiconductor production. According to Chinese state media outlet *Global Times*, South Korea is now actively trying to move away from these dependencies (Hu, 2024). This claim is not without substance. In fact, in 2023, South Korea recorded its first trade deficit with China in 31 years, accounting for 18 billion USD. Exports also fell from 155.7 billion to 124.8 billion USD (Hosokawa, 2024). In turn, exports to the US increased, overtaking China by slightly less than half a billion dollars (Kim and Kim, 2024).

This slow shift in trade destinations is accompanied by a strengthening of security relations with the US. In December 2022, the South Korean government unveiled its Indo-Pacific Strategy. The content of this new security approach was heavily influenced by the US. As one commentator noted: 'freedom, rules-based order, democracy, human rights and other values that the US has been promoting recently are underscored throughout the report' (Nam, 2022).

South Korea's incumbent government attempted to emphasize the 'inclusive' nature of its altered posture, not mentioning China directly but focusing on more neutral language. For policy-makers in Beijing, however, the message had already become clear through South Korea's purchase of a missile-defence system (THAAD) from the US a few years earlier, in 2017 (Shin, 2022).

Although justified by South Korea as a defence system against the North Korean nuclear threat, in China the purchase was seen as a direct attempt to weaken its deterrence capabilities (Swaine, 2017). China retaliated by blocking tourists from visiting South Korea, and Chinese tourism consequently dropped over 30 per cent between 2017 and 2020, thus diminishing a major source of income for South Korea (Kim S.-y., 2020). This number has recently recovered (Lee, 2023), but the incident has shown policy-makers in Seoul that China is willing to use economic coercion. This sentiment has extended into the semiconductor industry, as South Korean firms have shown they are now more willing to invest in the United States, despite the high costs this entails.

The US government announced the CHIPS and Science Act in 2022, authorizing 39 billion USD in federal incentives to promote its domestic semiconductor industry (117th US

Congress, 2022). This amount has now grown to over 52 billion USD in support, and over 24 billion USD in possible tax credits. However, there is one important condition for receiving this support: 'Recipients of CHIPS funds are prohibited from expanding manufacturing capacity in foreign countries of concern for ten years' (Pamilih, 2024). This list includes China.

For the two major South Korean chip firms, Samsung Electronics and SK Hynix, this formed a predicament, as both companies are heavily invested in production in China.

On 29 December 2021, Intel announced it would be selling off part of its memory chip business (NAND and SSD, see below for description) to SK Hynix, in a 7 billion USD deal that included transferring a major chip-making facility in Dalian, China (Intel, 2021). The complete transfer of intellectual property rights and personnel, including those working on location in China, would cost another 2 billion USD, and was expected to be completed by 2025 (SK Hynix, 2021). SK Hynix already had two other China-based production facilities in Chongqing and Wuxi when the US announced it export controls.

Samsung Electronics faced similar issues. In 2012, the company announced it would construct a memory chip plant in Xi'an, China, which started operations in 2016. In 2017, the company invested another 9 billion USD constructing an additional plant in Xi'an in order to produce more advanced chips (Yamada, 2017). By 2022, around 40 per cent of its NAND memory chips (see below for description) were produced there (Kim and Ting-Fang, 2022). Another plant, focused primarily on packaging semiconductors, is located in Suzhou (Samsung, n.d.).

For the time being, the United States has given Samsung and SK Hynix indefinite waivers to continue producing their chips in China and allowing the companies to supply their foundries with US equipment (Song, 2023). This has eased the immediate pressure.

However, it is clear that these stop-gap-measures will not be sustainable in the long term. Both Samsung and SK Hynix have therefore decided to shift their interests further to the US, and to apply for US-government support.

Samsung announced in April 2024 that it would expand its facilities in Texas after being awarded 6.6 billion USD in subsidies (Alper, 2024). In total, the company is expected to invest around 44 billion USD in US-based chip production (Jo, 2024). Similarly, SK Hynix

announced, also in April 2024, that it will be building its first chip plant in the US, with production aimed to start in 2028, and reserving a little under 4 billion USD to do so (Lee and Hawkins, 2024). SK Hynix will likely receive around 685.7 million USD in subsidies and special benefits while it awaits additional funds from the US Commerce Department, with the application under review at the time of writing (Jo, 2024). This shows that the South Korean chip giants are moving away from their China-based dependencies and leaning further towards supporting the United States in the decoupling process of the two superpowers.

The semiconductor landscape in South Korea

South Korea's semiconductor industry receives significant support and investments from the South Korean government to strengthen its position in the global market. Policies include measures focused on R&D, personnel development and international competitiveness. Through government support and several public–private partnerships, South Korea is looking to uphold its position as a major player in the global semiconductor market, while driving economic growth and technological advancement within the country.

In order to so, South Korea unveiled its K-Semiconductor Strategy (also referred to as the K-Semiconductor Belt) in May 2021. This strategy focuses on supply-chain disruptions, increasing global competition, and technological innovation. The plan aims to strengthen South Korea's position in chip production and establish Korean chip-makers as global leaders. It includes extensive support measures to help chip-makers navigate changes in the semiconductor supply chain caused by COVID-19. The collaboration between the government and private sector, backed by significant investments, has drawn considerable attention (*KBS News*, 2021). Interestingly, the 'K-Chip Belt' initiative was set up to create 'the world's largest supply network' by connecting semiconductor production centres to urban areas, with access to human resources, to support all aspects of chip development within a single region (*KBS News*, 2021).

To realize this plan, the South Korean government promised tax credits of up to 40 to 50 per cent for R&D spending and 10 to 20 per cent for facility investments, alongside a 1 trillion won (880 million USD) investment fund. These policies aimed at incentivizing over 510 trillion won (453 billion USD) in private investments by 2030 (Kang, 2021).

The South Korean government also provided infrastructure support to help companies expand in areas without existing chip clusters, including a ten-year water supply for factories in certain areas and coverage of up to 50 per cent of electricity costs by the government and South Korea's largest power utility, KEPCO.

However, as subsidies and tax incentive programmes spread, national security also rose higher on the political agenda. On 3 February 2022, the South Korean government passed the Special Measures Act on Strengthening and Protecting Competitiveness of National High-

Tech Strategic Industry (the National High-Tech Strategic Industry Act). Although the law provides tax deductions and expedites certain bureaucratic processes that are necessary for manufacturing advanced technologies (or 'strategic high-tech industries'), including semiconductors, the law was inherently designed to put companies that manufacture what South Korea's Ministry of Trade, Industry and Energy deems 'National High Technologies' (those important to national security) under further government regulations and protective measures (Yang and Chang, 2022).

These security concerns were later legitimized through a series of scandals. Among them was, very prominently, the arrest of a former Samsung executive, and former vice-president at SK Hynix, who was accused of leaking chip-related technology to China (Jo, 2023a). A total of seven people, including the former executive, were charged with stealing factory blueprints to build production facilities in order to replicate these in China (Kim T.-h., 2023).

The scandal enflamed public debates about securing semiconductor technology, leading to the South Korean government scrambling to introduce further protective measures targeting the industry. Although an eventual change of administration led to minor changes in the details of these measures, the main essence of the government's vision on semiconductors has, nevertheless, remained intact (Ebrahimi and Kang, 2023).

Importantly, on 21 July 2022, the South Korean government reiterated its focus on South Korea becoming a semiconductor superpower, outlining, again, a new strategy. It plans to invest more than 340 trillion won over a five-year period, providing support for developing factory infrastructure in semiconductor industrial parks and expediting construction permits, similar to previous promises. As part of this strategy, the government announced an expansion of its tax system support for equipment and R&D investment. In addition, the government highlighted human resource development as an important issue and stated that it aims to add more than 150,000 skilled workers over the next decade through various initiatives, including the founding of a specialized semiconductor academy and establishing research institutes utilizing unused equipment donated by companies (Abe, 2023).

Its goal is also to raise South Korea's domestic production from 30 to 50 per cent by 2030, thereby lowering dependencies on overseas production which currently accounts for roughly 70 per cent. The idea is to do this by securing leading non-memory semiconductor technologies and offering intensive support for next-generation semiconductors (Abe, 2023).

The latest policy to come into effect is the K-Chips Act, which was implemented in April 2023. The Act has rendered South Korea's semiconductor investment tax rate more competitive than in other semiconductor-producing countries, by increasing the existing tax credits for small-to-medium enterprises to 25 per cent and for medium-to-large enterprises to 15 per cent. In a temporary measure for 2023, chip-makers were eligible to claim an additional 10 per cent tax credit on investments made in the previous three years (Seo *et al*., 2023).

In January 2024, South Korea's Finance Ministry again announced further tax cuts for producers of strategic technologies, worth approximately 950 billion won, around 711 million USD (Im, 2024). Importantly, however, under the K-Chips Act these benefits are strictly limited to national strategic technologies, which includes semiconductors (Ebrahimi and Kang, 2023).[2]

In early 2024, South Korea announced its plan to create a 'semiconductor mega cluster' in southern Seoul by 2047, involving an investment of 622 trillion won (472 billion USD) that includes funds and support from Samsung Electronics and SK Hynix. The cluster will cover various industrial zones in southern Gyeonggi Province, spanning 21 million square metres, an area about as large as Disneyland Paris. The government plans to create specific zones for fabless companies,[3] establish foundry and memory chip production facilities in separate areas, and create specific zones for R&D and human resource development (Kang, 2024).

Although South Korea is currently strong in the memory chip market, the country plans to capture a 10 per cent share of the global non-memory chip market by 2030, a significant increase from the current projection of 3 per cent (Kang, 2024).

[2] For example, '15nm or lower DRAM design and manufacturing technology; 170-layer or higher NAND flash design and manufacturing technology; System on Chip (SoC) foundries manufacturing technology at 7nm or less; and vehicle, power and energy efficiency improvement chip designs and manufacturing technology'.
[3] Fabless manufacturing is the design and sale of semiconductor chips while outsourcing fabrication to specialized manufacturers.

In addition to establishing the mega cluster, the South Korean government has committed to enhancing the nation's self-reliance in key materials, parts and equipment supply chains, aiming for a 50 per cent self-sufficiency rate by 2030 compared to the existing estimate of 30 per cent, with a specific focus on decreasing South Korea's dependency on Chinese suppliers (Oh, 2023).

The semiconductor landscape in the Netherlands

The Netherlands has implemented a variety of policies to support the semiconductor industry, recognizing its strategic importance for the Dutch national economy. These are mostly focused on incentivizing investment in the sector, with a particular emphasis on R&D, the promotion of public–private partnerships, human resource development and a regulatory framework that incentivizes companies to remain or settle in the Netherlands.

For example, the *Nationaal Groeifonds*, or National Growth Fund, is a government initiative aimed at long-term economic growth and innovation. Implemented in 2020, it supports strategic investments in infrastructure, R&D and innovation projects that enhance the competitiveness of the Netherlands. With a budget of 20 billion EUR between 2021 and 2025, the programme therefore focuses on funding projects that drive economic growth, in particular projects that focus on long-term growth, have high start-up costs and contribute to specific priority areas, such as innovation, sustainability, digitalization, infrastructure and human resource development. To be eligible, companies must be involved in the development of new products or processes that require scientific or technical expertise (*Rijksoverheid*, n.d. a).

Similarly, InvestNL is a financing scheme that allows companies to apply for investments and loans for projects that can be deemed too risky or long term for private enterprises. Focus areas include technological innovation ('deep tech') and sustainable economic development. It provides up to 50 per cent of the initial capital, for an amount between 5 and 50 million EUR. Both large companies and small- and medium-sized enterprises qualify for the scheme. Although there is no clear cap for the fund, by the end of 2022 it had provided around 617 million EUR in investments and had secured 2 billion EUR in private investments in 65 companies and organizations (InvestNL, 2023).

The WBSO (*Wet Bevordering Speur- en Ontwikkelingswerk*, or Research and Development Promotion Act) is a tax incentive scheme that encourages businesses to invest in R&D activities. One caveat is that companies participating in the WBSO programme are required to monitor and report on the progress of their R&D projects to the Dutch government

to calculate the total tax credit. The programme had a total budget of 1.37 billion EUR in 2023, and 1.44 billion EUR in 2024 (RVO, 2024).

Another policy tool is the '*Innovatiebox*', or Innovation Box. Concretely, this is a tax incentive programme to promote innovation and support companies in investing in research and development activities. It offers preferential tax treatment for income from innovative activities, providing substantial tax benefits to qualified companies. Companies that apply must engage in R&D, the development of new products or technologies, patents, software development and other intellectual property-related activities. Companies must meet specific eligibility criteria, such as being resident taxpayers in the Netherlands or having a permanent establishment in the country (RVO, 2021). Similar to the InvestNL programme, both large companies and small- and medium-sized enterprises qualify for the scheme.

These subsidy and tax credit programmes are meant to strengthen R&D in the Netherlands, albeit not limited to the semiconductor industry. In January 2024, however, the Dutch government announced the National Technology Strategy, which labelled the semiconductor industry a critical sector (*Rijksoverheid*, 2024). As a critical technology, the Dutch government does focus on this industry in the implementation of the aforementioned policies (*Ministerie van Economische Zaken en Klimaat*, 2024).

Part and parcel of these programmes, however, is the idea that critical technologies also fall under national security. Identified as a 'key technology', the Dutch government recognizes its importance for the national economy and what it deems the 'public interest'. What this means is that such sectors 'can be subject to additional action' (*Rijksoverheid*, 2024).

This additional action came in the form of export controls on certain machines produced by ASML. These measures were announced in March 2023, following comments by the minister in charge that these were to be implemented for the sake of 'national security' (NOS, 2023a). Earlier in 2023, leaked diplomatic communication showed that this was the result of pressure from the US on the Netherlands (and Japan) to go along with stringent export controls against China (NOS, 2023b).

Nevertheless, later in the year, domestic political concerns were reinflamed when it became clear that a former ASML employee had, in fact, taken critical information to Chinese technology company Huawei (Hijink, 2023). According to ASML's president, the lost information was limited and only 'one piece of the puzzle', but it confirmed political concerns over ASML technology as part of the Dutch national security strategy.

Starting on 1 September 2023, the new restrictions were applied to ASML's exports of chip machines to China. Dutch Minister for Foreign Trade Liesje Schreinemacher announced that makers of chip machines, in particularly ASML, will need to apply for an export licence for particular models of the latest, and most advanced, chip-making equipment (Kasteleijn, 2023c).

The new measures allow the Dutch government to prevent exports to a particular country. Although the government refused to identify China as the target of these restrictions, it was clear that this was the policy's main intention (Kasteleijn, 2023c). Despite the clear political message, however, the impact on ASML is limited, as export restrictions for its latest EUV machines have already been in place for several years (Kasteleijn, 2024).

Notwithstanding this fact, a variety of policy shifts, including the export controls, have made ASML reconsider its place in the Netherlands. One factor is the change in the 'expat arrangement' that allowed skilled foreign workers to receive considerable tax benefits for working in the Netherlands. Companies could apply for a 30 per cent tax credit per employee with salaries up to 233,000 EUR per year, for a total period of five years, to compensate for travel and moving costs (*Rijksoverheid*, n.d. b).

The measure was put in place to attract more international talent to critical industries and to fill the growing gap in human resources and demand from the labour market. However, the Dutch government decided to lower the budget for the tax credit, reducing the five-year time-frame to a 20-month period at 30 per cent, then 20 months at a 20 per cent tax credit, and another 20 months at 10 per cent (*Rijksoverheid*, n.d. b).

The original arrangement was successful in attracting international talent. For this reason, large company federations, universities and individual companies openly complained about the changes, stating that the 'sobered' measures would deter foreign talent from coming to the Netherlands, thereby 'putting a brake on the innovative sectors' in the country

(Kraniotis, 2023). The issue escalated, and even the minister in charge publicly lamented the policy shift as 'unhelpful' (NOS, 2023c).

The worsening of the working climate for foreign talent was further exacerbated by statements made by prominent Dutch politicians concerning the internationalization of higher education in the Netherlands. At the time of writing, the Dutch party landscape was in a lengthy process of forming a new cabinet, following a landslide victory by far-right political parties (NOS, 2023d). Party leaders of the newly established majority have been, and remain, critical of the '*Verengelsing*', or increasing use of the English language in higher education, raising concerns that a new cabinet will further roll back earlier attempts at internationalization and make the Netherlands less attractive to foreign students and, in the long run, foreign talent (Seine, 2023).

This is part of a larger shift in the Netherlands, from opening up universities for foreign students, to closing them for the benefit of ostensibly protecting the Dutch language and Dutch students (van der Veere, 2022). The development of this type of xenophobia in Dutch national politics has raised considerable concerns among Dutch companies, which heavily rely on international talent. ASML's workers in the Netherlands, for example, are about 40 per cent of foreign origin (NOS, 2024b). As the numbers of relevant, skilled personnel continue to diminish within the Netherlands, foreign workers have come to make up an increasing portion of the Dutch labour market, especially in the technology sector, and most prominently the semiconductor industry, which employed over 40,000 people in 2021, and where there is a consistent shortage of university-educated personnel (Kusters and de Vries, 2019). In fact, the Netherlands has above-average growth in working hours in the semiconductor industry, with 12 per cent growth versus global growth of 10 per cent between 2020 and 2021 (Venture IQ, 2022).

The situation has deteriorated to the extent that semiconductor companies ASML and NXP have approached the Dutch cabinet to warn them of the worsening working climate in the Netherlands. ASML, in fact, has openly stated that it will consider leaving the Netherlands if the current situation continues. ASML executive Peter Wennink threatened the Dutch

government with 'having to relocate' if the company is not allowed to grow, calling it a growing 'divide between business and politics' (Nieuwsuur, 2024).

The Dutch government has taken the threat seriously. According to newspaper *De Telegraaf*, the government has formed a plan to keep ASML within Dutch borders, dubbed operation 'Beethoven' (Brandsema and Rigter, 2024). ASML has refused to respond to the plan, while the government stated that it was 'working in the interest of the public, the economy, and the labour market' (NOS, 2024b). Just weeks after ASML's threat to leave the Netherlands, the Dutch cabinet, and the municipality in which ASML is located, pledged to invest 2.5 billion EUR to improve the living and working environment in the region (Hofs, 2024).

European (EU) semiconductor policies

Dutch policies adhere, by and large, to policies implemented through the European Union. Although this is not wholly applicable, with national policies taking precedence under specific circumstances, the influence of EU policies remains significant in Dutch policy-making. For the semiconductor industry, several policy frameworks and financial assistance projects are applicable. This section briefly explores the most important of these.

Important Projects of Common European Interest (IPCEI)

The Netherlands contributes and participates in the Important Projects of Common European Interest (IPCEI) aid programme (RVO, 2022). This initiative was implemented to encourage EU member state cooperation in backing strategic industrial projects of mutual interest. The European Commission approved up to 8.1 billion EUR in 2023 for the programme (European Commission, 2023a).

Although applications are currently closed (temporarily), the IPCEI enables EU countries to uphold collectively large-scale projects in strategic sectors, such as advanced manufacturing, renewable energy, digital technologies and infrastructure, artificial intelligence and electric vehicles. The semiconductor industry is one of these strategic sectors (European Commission, 2023a).

In order to qualify, projects need to adhere to several conditions. These include cross-border collaboration, focusing on the aforementioned strategic sectors (see above), the potential for commercialization and scalability, and a strong commitment to the EU's environmental objectives of promoting energy efficiency and reducing carbon emissions. Projects that are part of the IPCEI need to combine the public funds provided with private investments. Countries are also allowed to provide additional incentives, such as tax credits, research grants and loans (European Commission, 2021a).

Two important caveats need mentioning: 1) each project is individually assessed and needs to be approved by the European Commission to ensure that it is up to regulatory

standards, with the Commission also looking at strategic relevance within the broader EU policy framework; and 2) approved projects are also monitored and evaluated for progress, impact and regulatory compliance. All key stakeholders are required to report to the European Commission (European Commission, 2023a).

EU Open Strategic Autonomy

The EU Open Strategic Autonomy initiative is a broad policy framework established to increase strategic autonomy, for example self-reliance, economic and security resilience, and to protect the EU's sovereign interests. The European Union defines strategic autonomy as 'the capacity of the EU to act autonomously – that is, without being dependent on other countries – in strategically important policy areas' (Damen, 2022).

The definition of the term, initially coined in reference to aligning security and defence policies among EU member states, has in recent years shifted to include economic security. This development took place in the context of a perceived 'rise of China', increasing economic dependence on Asia, and the potential for direct competition between Chinese and European businesses (Christiansen and Maher, 2017).

This process was exacerbated by the COVID-19 shocks to internationalized supply chains, spurring the inter-European political debate on the reliance of critical industrial sectors on non-European actors and the reshoring of production back to Europe. One sector identified as critical, yet strategically dependent on non-EU suppliers, was the semiconductor (chip) industry (Raza, Grumiller, Grohs, Essletzbichler and Pintar, 2021).

As discussed above, the increasingly complicated nature of producing chips has led to higher research, development and production costs. As a 2021 EU Commission Staff Working Document concludes: 'Designing and developing the most technologically advanced chips today can cost up to 1 billion EUR, while a leading-edge fabrication plant ('Fab') requires investments up to 20 billion EUR. This has led to a consolidation in the number of leading-edge chip manufacturers' (European Commission, 2021b).

With non-EU companies dominating the industry, and the EU having no foundries that mass produce the most advanced chips, the European Commission identified this as a critical industry that required special attention (European Commission, 2021b).

In 2021, the EU's Policy Department for External Relations therefore suggested 'reshoring' production of critical industries, such as semiconductors, back to Europe (Raza, Grumiller, Grohs, Essletzbichler and Pintar, 2021). As Raza *et al.* state: this is the 'process of bringing productive activities "home" to a specific location, while nearshoring refers to manufacturing being relocated to a country closer to "home"'. This process, however, has proven to be expensive and impossible to realize, as supply chains have grown increasingly international, complicated and fractured.

Economists at the World Bank, following an in-depth study, concluded that reshoring production capacity to high-income countries would be detrimental to the global economy and would result in tens of millions of people across the globe falling further into poverty. They posit that 'there is no sign yet that reshoring is happening on a large scale', but that policies that support the further diversification of international supply chains proved to be critical in rebounding from the economic shocks of the global pandemic (Brenton, Ferrantino, and Maliszewska, 2022).

Similar studies have drawn the same conclusion. As Poitiers and Weil argue, for example, 'providing support for research and development in chip design and software would be better suited to increase overall European value added and impact in the industry, compared to focusing on fabrication' (Poitiers and Weil, 2021).

Rather than a complete reshoring of production, therefore, we can see that the strategic decoupling of specific industries has now become the principal policy target. Concretely, the EU now focuses on minimizing reliance on external suppliers, particularly in vital sectors like technology, energy, health care and raw materials. The goal is to broaden supply chain options (for example, diversification of supply chains), boost domestic production capabilities, and ensure access to crucial resources for reduced vulnerability and risk management during disruptions or geopolitical tensions (Aarup, 2023).

As part of its effort to express allegiance to the EU's Open Strategic Autonomy, the Dutch government co-published a statement expressing its desire to counter 'unwanted knowledge transfer' (*Rijksoverheid*, 2023). The EU refers to this as the 'safeguarding' of critical technologies and knowledge and preventing their unauthorized use by other countries or non-state groups (European Commission, 2023b).

The EU wants to take steps to protect intellectual property rights, regulate foreign investments and enforce export controls in order to maintain Europe's strategic capabilities and security interests. In other words, the EU Open Strategic Autonomy is a semi-protectionist policy designed to protect the EU's strategic interests.

Critical Raw Materials Act

At the end of 2022, EU President Ursula von der Leyen announced the Critical Raw Materials Act (CRMA) in a state of the union address. In it, she specifically refers to semiconductors as a target industry, stating that: 'Whether we talk about chips for virtual reality or cells for solar panels, the twin transitions will be fuelled by raw materials' (von der Leyen, 2022). This strategy lists critical raw materials (CRM), including those used to produce semiconductors.

A 2023 review specifically mentions arsenic, borate, gallium, germanium, hafnium, helium and silicon metal, all used in the production of chips, as supply risks. With production of gallium ceasing in Germany in 2015, and the production of germanium ceasing in Finland in 2015, the EU's strategic dependence on China has grown for these materials. Global supplies have increasingly concentrated there, with China now supplying the EU with 71 per cent of its gallium and 45 per cent of its germanium (Grohol and Veeh, 2023).[4]

To ween the EU off its CRM dependencies, the CRMA sets goals to strengthen and diversify global supply chains. Concretely, it states that domestic capacity for critical raw materials by 2030 should be 'at least 10 per cent of the EU's annual consumption for extraction, at least 40 per cent of the EU's annual consumption for processing, at least 15 per cent of the

[4] It is important to note that materials that are defined as CRM change as supply and demand fluctuate. For example, while indium was deemed a CRM in 2020, it was removed from the list in 2023. However, arsenic and helium, not considered CRM in 2020, were added to the 2023 list in the latest review (Grohol and Veeh, 2023).

EU's annual consumption for recycling, and no more than 65 per cent of the EU's annual consumption [should come] from a single third country' (European Commission, 2023c).

Concretely, the EU wants to achieve these targets through two main policy tools: 'reduc[ing] the administrative burden [by] streamlining permitting procedures for critical raw materials projects in the EU'; and creating 'critical raw materials supply chain monitoring and stress-testing, coordinat[ing] strategic stocks and [setting] risk preparedness obligation on large companies producing strategic technologies' (European Commission, 2023c).

The problem with several of these raw materials used for semiconductor production is that they carry with them high ecological risks (Akarsu, Sönmez and Sivri, 2023). It is important to highlight here that the CRMA is part of the EU's larger Green Deal Industrial Plan (GDIP). In this overarching policy, the EU focuses on 'accelerating the transition to climate neutrality' (European Commission, 2023d). At the same time, the EU's demand for gallium and germanium, both ecologically harmful, continues to increase (see figure 1 and 2).

Nevertheless, the production of other CRMs has diversified significantly over recent years. In fact, dependency on China for rare earth materials, for example, decreased from 98 per cent in 2010, to 66 per cent in 2022 (Le Mouel and Poitiers, 2023). This sets an example for the possibilities of diversifying the supply of materials that are crucial in the semiconductor production process as well. This development, in fact, has set the stage for the European Chips Act, which specifically targets these areas of vulnerability.

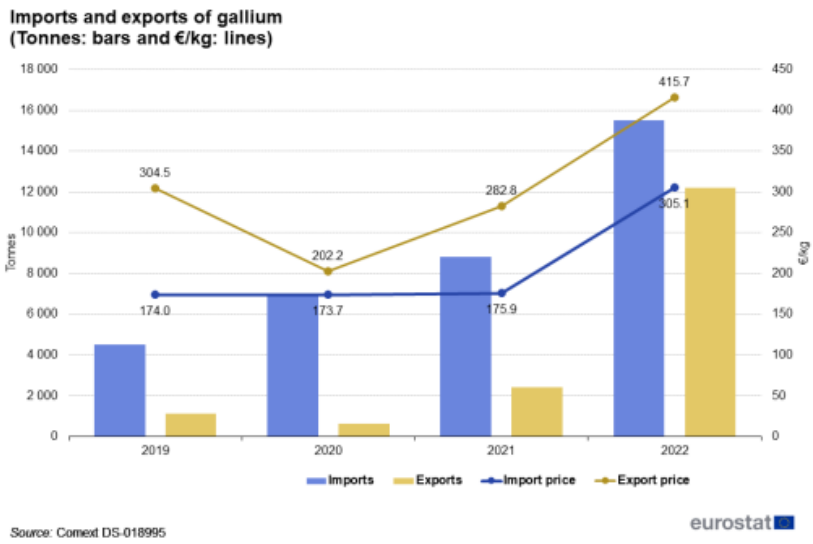

Figure 1: Imports and exports of gallium (weight and value).

Source: Eurostat.

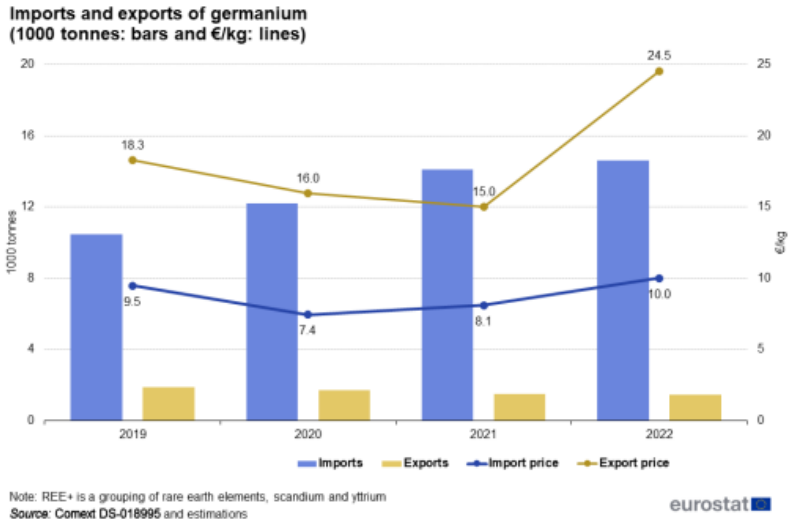

Figure 2: Imports and exports of germanium (weight and value).

Source: Eurostat.

The European Chips Act

Enacted in 2023, the EU Chips Act (ECA) aims to enhance Europe's independence in chip and semiconductor technology. It involves funding for research and development, investments in new chip-production capacities and monitoring markets to predict supply shortages. The overall budget for the initiative amounts to 43 billion EUR, to be used by 2030, with 11 billion EUR earmarked for R&D and innovation in the sector. The majority of the funding will be contributed by EU member states and businesses. In principle, the ECA consists of three main goals (or 'pillars').

The first goal aims at promoting R&D, as well as innovation in chip technology. It focuses on investing in R&D, including processes such as developing and improving chip design tools, and testing new chip technologies. It emphasizes the need to strengthen cooperation, and thereby create a so-called European ecosystem for chip design. This is to be achieved by encouraging collaboration between semiconductor companies based in the EU. Part of the measures include support training for professionals, skills development and intellectual property sharing arrangements.

The second goal is to establish a new legal framework to attract and fund large-scale investments in chip production in the EU. Legal provisions and financial support are made available to facilities that are state of the art ('first-of-a-kind') and are not already part of well-established industries or sectors within the EU. Although direct investments are not available through this scheme, and the assumption is that national or regional governments instead step in, the ECA provides a legal framework through which financial support can be more easily given to private companies in the semiconductor industry.

The third goal is to create a system to oversee the chips market and predict potential crises, as well as shortages in supply, using a mechanism called SCAN. According to the EU, SCAN is a method for assessing the risk of disruptions to supply chains using trade data and structural indicators. It is applied to a range of products in the semiconductor supply chain, identifying at-risk products. These are spread across various segments of the value chain, including raw materials, semiconductor manufacturing equipment and semiconductors (Bonnet and Ciani, 2023).

With the ECA only one year old, critics have already raised concerns about the policy's structure, funding and strategic orientation. Some argue that the ECA's funding may not be adequate to achieve its goals and question whether it is focusing on the right technologies. Additionally, there are doubts about the feasibility of attaining technological independence in chips, as reshoring production, even partially, can have devastating effects on the EU domestic market as well as the global economy. In fact, as Garcia-Herrero and Poitiers argue, it would be better for EU stakeholders to focus on key technologies in which they already maintain market dominance (Garcia-Herrero and Poitiers, 2022).

The primary criticism of the European Chips Act, however, pertains to its governance and funding framework, which lacks clarity regarding the sources of funding. Although it is stated that there will be an estimated policy-driven investment of over 43 billion EUR until 2030, the specific contributions from the EU level, member states and companies are unclear. There is also apprehension about creating competition among EU member states through granting 'first-of-a-kind' status for investment projects. Furthermore, there are doubts about whether the proposed budget will be enough to achieve the objectives set by the Act (Dachs, 2023).

Competition or collaboration?

As seen above, South Korea and the Netherlands are both important players in the semiconductor industry. It is important to note that companies in both countries have complementary roles within the semiconductor supply and value-added chains.

For example, while Samsung and SK Hynix have established themselves as market leaders in the production of memory chips, ASML is predominantly focused on semiconductor equipment manufacturing. Each company focuses on different segments of the industry, making them less prone to engage in direct competition.

Within the larger framework of global competition, however, there are factors that need to be considered. For example, both of the South Korean manufacturers compete globally with companies from the United States, Taiwan and Japan for market share and revenue. The Netherlands competes within the semiconductor equipment market against companies from the United States, Japan and Germany.

This provides several opportunities for cooperation, on which leaders in both South Korea and the Netherlands are trying to capitalize. South Korean President Yoon Suk Yeol announced that South Korea and the Netherlands have agreed to enhance their collaboration in the semiconductor industry to an industrial alliance level, encompassing public and private sectors, as well as academia. In fact, Yoon's 2023 visit to the Netherlands, which lasted four days, was focused on ensuring a stable supply chain of key materials, such as semiconductor production equipment, and expanding bilateral semiconductor industry cooperation (Kim E.-j., 2023).

After Yoon's announcement, the Netherlands followed suit in confirming a plethora of agreements, with collaboration in the semiconductor industry being the most important theme, as the establishment of direct working-level dialogue channels between the two governments shows (Ministry of Foreign Affairs, 2023). This deal was substantial, as it also involved ASML and Samsung pledging 760 million USD to this 'semiconductor alliance' (Kim J., 2023).

The chairman of Samsung Electronics, Lee Jae-yong, also joined the presidential visit to the Netherlands and expressed his contentment with the deals reached, as he met with Dutch leaders and top executives of ASML to facilitate the agreements. Significantly, Samsung was able to secure a priority order for ASML's latest EUV machines, which are considered crucial for global chip suppliers and are in high demand because of ASML's limited production capacity (Jo, 2023b).

This is part of a broader strategy by South Korea to deepen collaboration with the EU. For example, in March 2024 South Korea and the European Union agreed to collaborate on research projects focusing on advanced semiconductor and next-generation communications network technologies over the following three years (Kim N.-y. , 2024).

Importantly, education and human resource development are important issues. Following Yoon's visit to the Netherlands, the two governments agreed to cooperate in establishing an R&D centre in South Korea, where graduate students from both countries will work on advancing semiconductor technology. In the past, ASML had already provided educational cooperation to SK Hynix, which in 2022 started an overseas working and training programme to help its employees have a broader perspective of the global semiconductor industry (*The Korea Herald*, 2022).

The scope, however, has now expanded significantly. In concrete terms, policy-makers discussed plans to develop 500 specialists from both nations by 2028 through an educational programme that recently engaged 60 graduate-school students (Oh, 2024).

The reason for this focus on educational exchange is that South Korea faces a chronic shortage of talent. According to a report by its Ministry of Education, South Korea will fall short by 31,000 workers for the semiconductor industry by 2031 (Yoon and Shim, 2024). This problem is not isolated to South Korea, but is a global problem.

According to a survey by Deloitte, over one million workers will be needed by 2030 to keep up with the growing demand for human resources in the global semiconductor industry (Weisz *et al.*, 2022). Consequently, one of the goals of the EU Chips Act is to establish so-called 'competence centres' to attract and educate more talent to work in the industry (Haeck, 2023).

The Netherlands is facing the same predicament, with personnel shortages putting pressure on multiple critical industries, among them the semiconductor industry. Although ASML recently announced that it would decrease the number of new hires, this was largely the result of unrestrained growth and difficulties with onboarding new workers – the company hired 20,000 new workers in 2022 alone – in a limited timeframe (Kapteijns, 2023).

However, the Brabant region of the Netherlands, in which ASML is situated, along with most other major semiconductor companies, continues to struggle with massive human resource shortages, a situation that is likely to worsen in the coming years (Vossen, 2024).

Nevertheless, the Netherlands has remained strong in attracting foreign talent overall, with around 30.4 per cent of its workforce coming from abroad. For the academic year 2023–2024, almost 90,000 foreign students were enrolled in Dutch institutions of higher education (Puylaert, n.d.).

According to a recent study by the Rathenau Institute, the Netherlands' university population consists of 14 per cent foreign students, with about 15 per cent of these students choosing a technical or IT-based career path. This has a positive net economic outcome for the Dutch economy, with one out of every five international students choosing to remain in the Netherlands after graduation (Demirel, Koens and Vennekens, 2024).

South Korea has also invested in attracting more international talent. The government has stated its intent to attract 300,000 foreign students by 2027 (ICEF Monitor, 2023). In fact, South Korea saw the enrollment of 182,000 foreign exchange students in 2023, up by 15,000 students compared to 2022 (Lee J.-j., 2024), although this has still fallen short of the original goal of attracting 200,000 foreign students by 2023.

Nevertheless, compared to international student numbers at the start of the century, which was only around 12,000 in 2001, the significant increase in the total number of foreign students shows that South Korea has already seen success in internationalizing its institutions of higher education (ICEF Monitor, 2015).

Educational cooperation, international student and expert exchanges, and personnel development are issues that offer significant collaborative opportunities for the Netherlands

and South Korea. However, as discussed earlier in this report, the Dutch government has recently become increasingly hostile towards international students, and migration issues as a whole. The effects of this political shift against internationalization efforts have affected the prospects of semiconductor companies based in the Netherlands. This will become the greatest challenge to deepening collaboration with South Korea.

Conclusion and recommendations

US–China decoupling has significantly affected the state of the semiconductor industry. Although this extends to the entire industry, this report focuses on two key players in particular: the Netherlands and South Korea. Both countries have been affected by recent developments. They have shifted their strategies and implemented a set of policies both to stimulate the domestic sector as well as to 'protect' critical technologies, such as advanced semiconductor technology.

For the Netherlands, export limitations put in place following pressure from the United States to limit Chinese access to sensitive technology have burdened the Netherlands' most important technology company, ASML. Although current restrictions have not significantly affected ASML's output, as of the time of writing, further restrictions are likely to be implemented as decoupling progresses. In South Korea, pressure from the US government to build facilities in the United States has seen companies like Samsung and SK Hynix invest billions of dollars in the construction of new specialized fabrication facilities for the production of semiconductors (known as 'fabs').

Both the Netherlands and South Korea have made major policy changes in the past few years, and key stakeholders (such as semiconductor companies) are following suit. There are, nevertheless, significant challenges that remain. The Netherlands is reliant on Chinese trade in the sector, and the same can be said of South Korea. In fact, South Korean companies are heavily invested in China-based production facilities that, because of new restrictions by the United States, cannot be updated. In the Netherlands, the selling of certain models of semiconductor production machines made by ASML have been limited in terms of sales to China, a major client state. Both the Netherlands and South Korea are, therefore, in a similar predicament in terms of decoupling effects.

Although Dutch and South Korean companies are competing in certain parts of the semiconductor supply chain, they are, by and large, not major competitors in the industry as a whole. In fact, the two countries can be seen as complementary. This creates opportunities for collaboration.

South Korea has shown its willingness to deepen ties with the Netherlands, as evidenced by President Yoon's visit. A plethora of arrangements and promises followed, with significant developments in terms of business-to-business cooperation as well, as shown by ASML's acceptance of Samsung's orders for production equipment.

Importantly, stakeholders have expressed their willingness to strengthen collaboration in terms of knowledge exchange: mostly in the form of exchange programmes involving students, experts and professions. Both countries, however, are also heavily invested in the development of international talent (for example, human resource development).

Although worker shortages are an industry-wide problem, the Netherlands has quite successfully attracted foreign talent to come and study, and to work long term, in the Netherlands. South Korea, similarly, has succeeded in growing its pool of foreign exchange students coming to study in the country. Together with technology companies, South Korea is now investing large sums in building facilities for the education of workers for the semiconductor industry, specifically.

In the Netherlands, investments have also taken place, both public and private. In May 2024, ASML promised to invest over 80 million EUR over a period of ten years to further R&D at an adjacent university, the *Universiteit Eindhoven* (Hijink, 2024). Similarly, the Netherlands adheres to the EU Chips Act, which dictates the opening of educational institutions to develop human resources in each EU member state. These policies therefore align well. Herein lie opportunities to deepen ties.

However, the current political climate in the Netherlands forms a significant risk. As described earlier in this report, hostility towards international students and internationalization in education are risks to decreasing worker shortages for semiconductor companies, which are in constant need of new talent. The recent end of the '*expatregeling*' – financial incentives for hiring international talent – is one example of the Dutch government removing incentives for skilled foreign workers to settle in the Netherlands, a development about which semiconductor companies have openly expressed their concerns (van der Leij, 2023).

The EU policy for reshoring production also forms a risk. Rather than focusing on reshoring, Dutch stakeholders would be better off in their current role of supporting clients and partners and concentrating their efforts on strengthening the specialized portions of the semiconductor supply chain in which the Netherlands now maintains a significant market share, as per Garcia-Herrero and Poitiers' argument (Garcia-Herrero and Poitiers, 2022). For this, however, scientific collaboration and international knowledge exchange are critical aspects. The Dutch government has partially identified these risks in its recent National Technology Strategy (Rijksoverheid, 2024). Nevertheless, it seems that current Dutch political actors are overlooking the long-term risks of continuing the present trend towards isolating Dutch higher education from international talent, and are thereby destabilizing human resource supplies to the semiconductor industry, an area in which the Netherlands could strengthen cooperation and deepen ties with partner countries, such as South Korea.

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Appendix I: What are semiconductors?

This section briefly explores some of the key terms used in this report. Most importantly, it answers the question: what are semiconductors and why do they matter so much? In short: they are unique materials that can control the flow of electricity.

Semiconductors can be used like a switch. By applying a small amount of electricity, they can either allow the current to pass through (turning the switch on) or halt it (turning the switch off). These switches are called transistors. This characteristic makes semiconductors highly valuable for constructing electronic devices. They are essential for smartphones, computers and televisions, as they control electricity flow and handle functions such as data processing and storage.

Semiconductors allow the miniaturization of electronic components, resulting in smaller, often portable devices. They help reduce energy waste by improving energy efficiency, as power consumption can be controlled through these devices. Consequently, they are a key component in renewable energy technologies.

However, use of semiconductors is most common in communication technologies such as computers, smartphones, satellites and the internet, as they help in processing and transmitting signals within (tele-)communications networks. The most advanced versions are therefore used in cutting-edge technologies, such as 5G networks, military-grade weapons and the hardware that enables artificial intelligence.

Semiconductors have a wide range of nomenclature, but are most commonly referred to as chips, microchips, computer chips or microprocessors. There are various forms that these can take. The most commonly used are: 1) logic chips, which process information and specific tasks; 2) memory chips, which store information; 3) ASICs, which are single-purpose chips that are used for 'performing repetitive processing routines such as scanning a barcode'; and there are also 4) system-on-chips, which are combinations of the previous three chips and can be used for complicated tasks, such as graphics processing (ASML, 2024).

These chips have become increasingly small and complicated over time. This miniaturization phenomenon is commonly referred to as Moore's Law, named after Gordon Moore, co-founder of Intel, who observed in 1965 that the number of transistors on a

microchip double approximately every two years (Intel, 2024). In fact, while the average number of transistors on a chip stood at a little over 2,000 in 1971, this number reached 58.2 billion in 2021 (Rupp, 2022).

The size of each transistor has become so small that they are currently measured in nanometres (nm), a unit of measurement used to quantify length on a nanoscale: one billionth of a meter. For scale: Intel promised in 2022 to deliver chips by 2030 that have one trillion transistors, each about three atoms thick (Intel, 2022).

Producing these chips has, as a consequence, become incredibly complex and costly. Only a few companies in the world are now able to produce chips on a scale that is profitable. Currently, most chip producers have stepped away from the high-cost production process, leaving only a handful of chip-producing companies, most importantly TSMC (Taiwan), UMC (Taiwan), Intel (US), GlobalFoundries (US), SMIC (China), Samsung (South Korea) and SK Hynix (South Korea).

In addition, even fewer companies are able to produce the equipment needed to manufacture semiconductors. US-based Applied Materials, Lam Research and KLA-Tencor hold over 40 per cent of the market, while 'ASML (the Netherlands) and Tokyo Electron (Japan) together account for another third of the market' (Bown, 2020).

Companies that are involved in the semiconductor production process but that do not have their own fabrication capacity (or foundry) are called 'fabless'. These include large companies like Broadcom, Qualcomm, Nvidia, AMD and MediaTek, which design new chips and hold intellectual property rights (Gratton, 2024).

It is important to note that companies can be involved in different steps of the supply chain. A more detailed explanation, including various case studies, of the complexities of the semiconductor supply chain can be found in a previous LeidenAsiaCentre study conducted by Lammertink *et al.*, Dutch Semiconductor Interests in Asia.

In short, semiconductors are complex pieces of technology that are incredibly complex to produce and have become an essential building block for modern technology and, in turn,

modern society. They are, for that reason, a focal point in increasing political tensions across the globe.

Appendix II: Major semiconductor companies in South Korea

The semiconductor industry in South Korea is dominated by two multinational companies: Samsung and SK Holdings. Although the companies both have diverse product portfolios, they each have subsidiary companies that focus on the production of chips: Samsung Electronics and SK Hynix, respectively. As a result of the growing success of these chips in the global market, South Korea has been able to edge into a leading position globally, responsible for over 70 per cent of the global memory chip market (Song S.-h., 2021). Below is a brief overview of these companies.

Profile: Samsung Electronics

Samsung Electronics is a major technology company focused on consumer electronics, IT and mobile communications, home appliances and semiconductors. Its semiconductor division plays a significant role globally by designing, developing, manufacturing and selling memory chips, system-on-chips, and display driver integrated circuits. The company produces various types of memory chips, including DRAM (Dynamic Random Access Memory)[5] and NAND Flash Memory.[6] The company also designs and manufactures system-on-chips for, among others, mobile devices and automotive applications. Its main staple, memory chip production, has given it an internationally dominant market position. Samsung Electronics primarily operates its production facilities in South Korea and China, with advanced fabrication plants (fabs) and assembly and testing facilities. The company invests heavily in research and development.

[5] DRAM is a type of volatile memory that needs continuous power to keep stored data. Unlike non-volatile memory such as Flash Memory, DRAM loses its data when the power is turned off. DRAM chips have fast access times, which make them suitable for use as the main memory in computing systems.
[6] NAND Flash Memory is non-volatile, meaning it retains stored data even when power is turned off. This makes it suitable for storage applications where data persistence is essential, such as in solid state drives (SSDs) and memory cards. NAND memory offers high storage density, allowing for large capacities in compact form factors, making it practical for use in data centres and consumer electronics.

Profile: SK Hynix

SK Hynix, headquartered in South Korea, is also one of the world's largest semiconductor manufacturers, primarily focused on designing, developing and manufacturing memory chips such as DRAM and NAND memory.[7] These chips are components used in electronic devices such as smartphones, computers, servers, solid-state drives and consumer electronics. It also develops other semiconductor products such as CMOS image sensors and system-on-chips. The company runs advanced semiconductor manufacturing facilities in South Korea and China.

[7] The company makes a wide range of DRAM products, including DDR4, DDR5 and LPDDR4X, all with different capacities and speeds, used in a wide-range of end-products.

Appendix III: Major semiconductor companies in the Netherlands

The Netherlands hosts semiconductor manufacturing facilities and research institutions, including companies like ASML, which is a leading manufacturer of photolithography equipment for semiconductor fabrication. The Netherlands' location, as well as its well-developed infrastructure, transportation networks and favourable business environment attract investment and support semiconductor-related activities in the region. In addition, the Dutch government actively supports the semiconductor industry through R&D grants, tax incentives and innovation programmes.

The Dutch semiconductor industry is diverse and comprises a range of companies that focus on different facets of the semiconductor production process. Below is a brief overview of the most important semiconductor companies based in the Netherlands, with a focus on the four largest that make the bulk of the country's revenue in the industry: ASML, ASM International, NXP Semiconductors and Nexperia. For a full overview of the Dutch supply and value chains, please refer to Lammertink *et al.* (2023).

Profile: ASML

ASML is one of the world's leading suppliers of photolithography equipment, which is essential to produce integrated circuits (ICs) or computer chips. The company's equipment uses advanced technologies such as extreme ultraviolet (EUV) lithography, deep ultraviolet (DUV) lithography and immersion lithography to pattern intricate circuitry onto silicon wafers. Importantly, the company's equipment facilitates the production of increasingly smaller and more energy-efficient chips.

These chips are used in increasingly advanced computing, communication, consumer electronics and automotive technologies, and with potential use for advanced weapons technology, making it sensitive technology. The company's photolithography systems are a crucial component of the semiconductor supply chain, positioning ASML as a key player in the industry.

Consequently, ASML collaborates with top semiconductor manufacturers globally, including Intel in the US, Samsung Electronics in South Korea and TSMC in Taiwan (ASML,

n.d. a). Although headquartered in Veldhoven, the Netherlands, ASML has over 60 offices worldwide. These are predominantly located in countries with a strong presence in the semiconductor supply chain, particularly in Asia. In China, it maintains thirteen locations, in Japan it has seven offices, Taiwan counts six locations (including two factories) and South Korea has six offices (ASML, n.d. b).

The company is known for its substantial investments to sustain its competitive position in the market, being the largest R&D investor in the Netherlands (Verrijt, 2019). ASML experienced strong sales in 2023. In the first quarter, its sales reached 6.7 billion EUR compared to 3.5 billion EUR in 2022. The company's profit also soared to about 2 billion EUR from a year earlier. Both revenue and profit exceeded expectations because of accelerated installation of systems at customers' facilities, as reported by ASML. Despite a recent decline in orders, the chip-maker still held an order backlog worth some 39 billion EUR at the end of 2023 (Kasteleijn, 2024).

Annual sales eventually reached 27.6 billion EUR in 2023, with profits exceeding the previous year's figures at almost 8 billion EUR (compared to 5.6 billion EUR in 2022). Additionally, there was a significant increase in the number of orders towards the end of 2023. Chinese manufacturers were ASML's primary revenue source in the latter part of 2023 (Kasteleijn, 2024). ASML underscores that these machines had already been ordered for 2021 and 2022, with approximately half unable to be delivered because of worldwide chip shortages. Additionally, these machines are not subject to export limitations.

Profiles: ASMI, NXP and Nexperia

ASM International, abbreviated as ASMI, produces equipment and process solutions for making integrated circuits or computer chips. The company focuses on equipment and technologies for semiconductor device production, supplying chip manufacturers, foundries and research institutions. The company is also heavily invested in R&D. It actively collaborates with industry partners, universities and research organizations to develop new materials, processes and equipment solutions for the semiconductor industry (ASM International, n.d.).

NXP Semiconductors is a semiconductor manufacturer that focuses on designing and producing semiconductor solutions for the automotive, industrial, Internet of Things (IoT), mobile and communication industries. It is primarily active in industrial automation, smart homes, smart cities, mobile devices and communication infrastructure. NXP publicizes the security and privacy features in its products. The company's secure elements and embedded security solutions are extensively used in applications such as mobile payments, eGovernment, access control and IoT devices to protect sensitive data from cyber threats (NXP, n.d.).

Nexperia is a semiconductor company based in Nijmegen, the Netherlands. It specializes in designing, manufacturing and supplying discrete semiconductors and logic devices for different applications. Established as an independent entity in 2017, Nexperia was originally part of Philips. The company's components are used in various industries, including automotive, industrial, consumer electronics and telecommunications (Nexperia, n.d.)