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# Made in NL

The value of the Dutch

high-tech manufacturing industry

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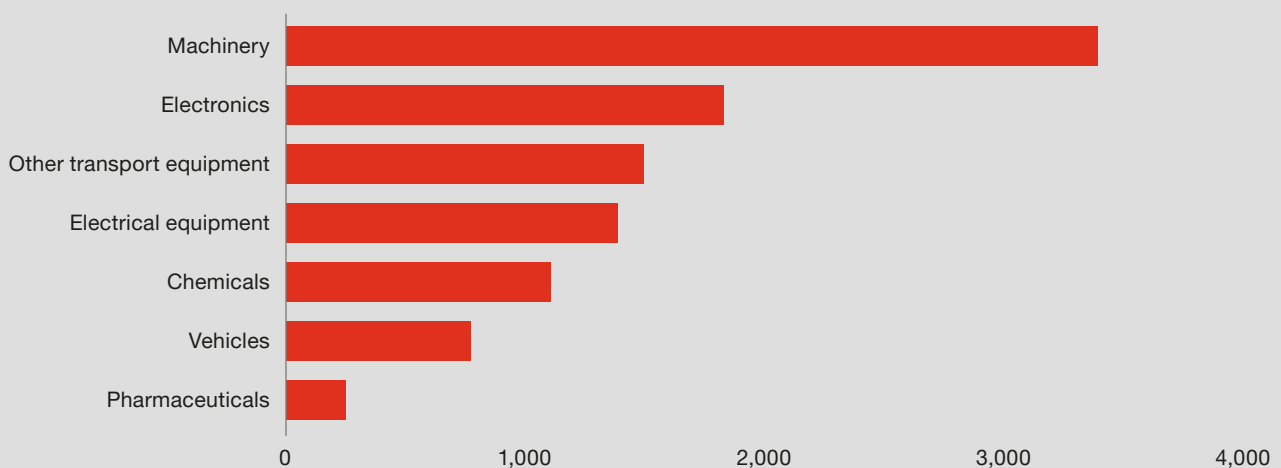
# The high-tech manufacturing industry in focus

In this report we focus on the high-tech manufacturing industry. We hereby follow the Eurostat definition of high-tech manufacturing, which includes the following high- and medium-high-tech manufacturing industries: chemicals, electrical equipment, electronics, pharmaceuticals, machinery, other transport equipment and vehicles.<sup>1</sup>

There are around 10,300 such high-tech manufacturing companies in the Netherlands, with most present in the machinery (for example, ASML) and electronics (for example, NXP) industries (Figure 1).<sup>2</sup> For further explanation we refer to the appendix on page 43.



**Figure 1** The seven high-tech manufacturing sub-industries include 13.5% of Dutch manufacturing companies



Source: CBS, PwC analysis.



# Foreword

The Dutch style of collaboration between the government and the high-tech manufacturing industry is favorable for long-term prosperity.

## The high-tech manufacturing industry is of crucial importance for the long-term welfare and prosperity of Dutch society...

Research has shown that manufacturing, including high-tech manufacturing, remains a key engine of economic growth, even if its share of GDP is gradually declining, as advanced economies tend to become more oriented towards services.<sup>3</sup> The high-tech manufacturing industry has a direct contribution to national income, employment and tax revenues. Measured in terms of added value, the importance of the Dutch economy is six percent, but the value for society is more than that. Less visible but equally important, this industry typically tends to create positive spill-over effects as its activity creates jobs and revenues elsewhere – the so-called economic multiplier effect. High-tech manufacturing produces many innovations to deal with long-term challenges, from providing affordable healthcare and decarbonising the energy system to building sustainable food provision. High-tech manufacturing is an obvious place for young talents to help shape and form the skills needed now and in the future, and is therefore a great training ground for the workforce of the future, of all education levels.

## ... and is essential for a resilient economy in a fractured world

Having a well-functioning and agile high-tech manufacturing sector greatly enhances the resilience of the economy. The Netherlands, as one of the most open economies in the world, is confronted even more than other countries by global fragmentation. Geopolitical tensions and their consequences for the relationships between countries and global trade make the successful Dutch earning model more complex and costly. To be resilient to future global shocks, a prosperous high-tech manufacturing industry is essential.

## The success of the high-tech manufacturing industry is partly the outcome of a Dutch-style private and public co-existence

The Netherlands has long prided itself on a Dutch-style form of co-existence between the government, the corporate sector and knowledge institutions: the so-called ‘triple helix’. It has delivered an industry that stands out in the world in terms of innovation, productivity, dynamism, and economic performance. Perhaps the most eye-catching achievements of all – projects such as Deltaplan, building Flevoland, or putting an entire gas grid in difficult soil within only a few years – could not have been achieved without this efficient

and effective co-existence. Apart from those, the Netherlands has not only brought forward an impressive list of globally recognised highly prized brands but also an array of so-called ‘hidden champions’. In fact, the Netherlands has managed to develop more than one economic cluster or ecosystem proven to be virtually incontestable for global competition.

A lengthy list of geographic, sociological, and geological factors has contributed to this success, but it is undisputed that the Dutch-style triple-helix model has been playing a significant role too. A co-operation that is fruitful for long-term prosperity and societal welfare obviously does not mean that all the interests of all parties are always parallel. Nevertheless, a good understanding of each other’s objectives and roles and a clear common vision of long-term preferred outcomes are essential.

## The co-existence model has not been working as well as it once did

Today, there are strong signs that the co-existence model between the government and the business sector is not working as well as it once did. This also applies to the high-tech manufacturing industry. The appreciation of the crucial importance of the production sector by society in general and politics is no longer taken for granted. This decrease in appreciation threatens fruitful collaboration and, consequently, long-term earning capacity and prosperity.

Companies complain about the policy machinery. And while some flagship brands have already left the Netherlands, several others are publicly questioning whether they should not do the same or at least do their next investment elsewhere. The Dutch government, on the other side, faces a set of dilemmas that involve choices that directly or indirectly affect the location decisions of companies that compete on global markets. Dilemmas arise because manufacturing, including the high-tech manufacturing industry, also brings costs to the economy and society. Manufacturing struggles to decarbonise, is engaged in the war for talent and takes up scarce physical space.

Standing up straight to defend the interests of private companies does not pay off politically for members of parliament or ministers. The wider public has been confronted with the consequences of misconduct and careless behavior or has suspicions that societal interests have been disregarded and corners have been cut, driven by short short-term profit maximisation. It should be no surprise then that trust in large companies has declined year after year since 2012.<sup>4</sup>



### Re-establishing co-existence

One key to regaining trust, we think, is making the full story better known. Understanding the role, importance and wide array of positive effects that high-tech manufacturing has while acknowledging where there are conflicting interests, might contribute to a better appreciation of the value of the industry. We do not have the illusion that this immediately solves the relationship problems between government and manufacturing industry, but the story must be told much, much better. And the high-tech manufacturing industry has great stories to tell. Those stories can help create more pride, more positive attention, more trust and a larger fanbase in all parts of society. At the same time, the industry should resist the temptation to play down the potential negative effects it causes. It should rather explain more explicitly what it does or will do to mitigate those effects. And naturally, it should avoid cutting corners at all costs.

### In this report, we present an overview of the economic significance of the high-tech manufacturing industry

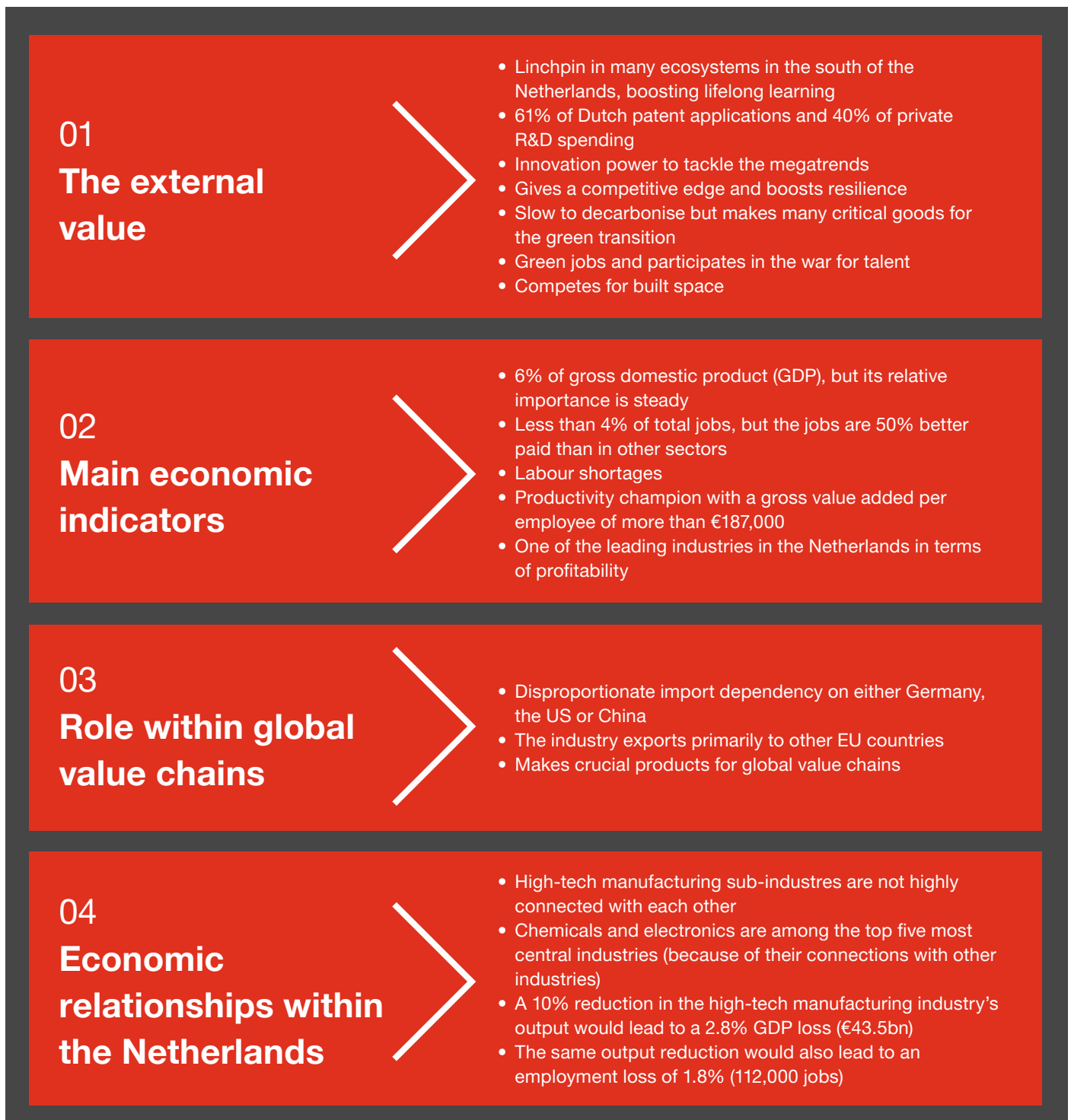
This study is based on many conversations we have had with about thirty high-tech manufacturing companies, interest organisations, research institutions and government

organisations. We have tested and supplemented their statements as much as possible based on data. The report aims to describe the contribution of the high-tech manufacturing industry to society and the economy more broadly, beyond the direct effects and including the indirect knock-on economic effects and societal multipliers such as innovation, education, productivity and contributions to megatrends.<sup>5</sup> The study addresses the roles that the government and the industry can play in optimising the co-existence between the two, against the backdrop of our greater challenges.

The result is a story about the broad value and positive and negative impact of the high-tech manufacturing industry. When we take stock, we see that this value is significant and essential for the economy and society. Therefore, we hope that this study contributes to the discussions about the desired form and content of our high-tech manufacturing industry for the greater long-term good.

**Jan Willem Velthuisen**  
**Jeroen van Kessel**  
**Mathieu Rosier**  
**Robert du Burck**

**Figure 2** Benefits and costs of the high-tech manufacturing industry



# Executive summary: a relatively small industry with a big impact

This report answers the question: What is the economic and societal value of the Dutch high-tech manufacturing industry? To answer this question, we analysed the value of the Dutch high-tech manufacturing industry from four perspectives: the **external value of the high-tech manufacturing industry**, the **main economic indicators**, the **role within global value chains** and the **economic relationships within the Netherlands**. We considered the historical developments of the high-tech manufacturing industry and the international dimension, comparing it to the same industry in Belgium, the United Kingdom (UK), France, Germany, the European Union (EU) average and the United States (US).

We conducted more than **30 C-suite interviews** with key companies in the industry, government representatives and research institutions.

**The external value of high-tech manufacturing: an important driver for innovation and growth, while struggling to decarbonise and competing for talent and space**

The Dutch-based high-tech manufacturing industry has a very positive indirect impact on education and on the innovative power of the Netherlands. It is a linchpin in the several ecosystems in the Netherlands that combine research, the private sector and the government, forming the triple helix model of innovation. This is most notably the case in the southern region, but other successful ecosystems are found throughout the country.

Sixty-one percent of Dutch patent applications and 40% of private R&D spending come from the high-tech manufacturing industry. The industry is therefore an important driver behind the innovative power of the Netherlands. And when the industry innovates, it is not only the companies themselves that benefit, as numerous innovations become public goods that can be shared across the value chain.

The proliferation of innovations doesn't stop at manufacturing. They also spill over to the service sector. It can be argued that without an innovative manufacturing industry, a mature, advanced services sector wouldn't have access to the innovations needed to drive productivity, quality and competitiveness. Think only about the most advanced computers and mobile phones.

Furthermore, many of the key innovations in the industry are and will be necessary to tackle the big challenges that the world faces today, like climate change, food security and caring for an ageing population. Moreover, the high-tech manufacturing industry contributes to the resilience of a country or region and makes it less dependent on production assets in foreign countries.

At the same time, the high-tech manufacturing industry also has negative external effects. Although greenhouse gas intensity has significantly decreased over the past decades, its reliance on fossil energy and, therefore the share of greenhouse gas emissions is still substantial. In addition, the geographically concentrated success of the industrial clusters has exacerbated the already tight labour market and the war for talent in the economy. The same holds for the intensifying of the competition for infrastructure, from roads to power connections, and built space in the Netherlands. Several companies that have enjoyed rapid growth in recent decades have come to realise that they cannot fulfil their business ambitions without engaging with the surrounding community. Earning a licence to operate today requires different tactics and strategies than would have worked a few decades ago.

**Main economic indicators: high-tech industry is not a jobs machine but a productivity champion**

At first glance, the high-tech manufacturing industry makes up a relatively small share of the overall Dutch economy: 6% of GDP and less than 4% of total jobs. However, the industry in the Netherlands has retained its economic size better than the same industry elsewhere and is becoming a more important part of the Dutch manufacturing sector. Furthermore, although high-tech manufacturing creates a relatively low number of jobs, these jobs are better paid than elsewhere: the industry pays 50% more than services or the rest of manufacturing.

The high-tech manufacturing industry is a 'productivity champion'. This industry has almost doubled its gross value added per employee, from more than €100,000 in 2000 to more than €187,000 in 2022, and these numbers are higher than in Germany, France, the UK, Belgium or the US.

It has been one of the leading industries in the Netherlands for the past two decades in terms of profitability. Moreover, its capital expenditures make up 6% of the total in the Netherlands.<sup>6</sup> In addition, foreign investors have been steadily exiting the Dutch high-tech manufacturing industry, some silently, others explicitly. This trend is similar elsewhere in the EU.

### The role within global value chains: import dependency on a few countries makes the industry vulnerable

Already for centuries, the Netherlands has been heavily integrated into global value chains, and today this applies to an even greater degree to the high-tech manufacturing industry. Looking at its foreign trade relationships, its imports and exports account for around 20 to 25% of total Dutch imports or exports, while its GDP share is only 6%.

There is a difference, however, in how the import and export relationships have been shaped. On the import side, the high-tech manufacturing industry has a disproportionate import dependency on either Germany, the US or China. This can be seen as a potential source of vulnerability for the future. On the export side, things seem more comfortable as the primary export countries of the industry are predominantly other EU member states. However, big outliers are the machinery industry, which exports most to Taiwan (the Republic of China), China, Korea and the United States and the other transport equipment industry, which exports mainly to India.

Both on the import and export sides, the high-tech manufacturing industry has large trade dependencies outside of the EU. In times of rising protectionism and geopolitical tensions, the industry can become vulnerable.

Many high-tech manufacturing firms might not sell a large volume of goods compared to other industries, but the products that they sell are pivotal to the production of many other goods globally. With that being said, controlling strategically important global value chain chokepoints is essential to the global competitiveness of the high-tech manufacturing industry and the Netherlands. At the same time, it is risky to just rely on holding those positions while technological and geopolitical trends accelerate, making the current dominant position uncontested in the long run.

### The economic relationships within the Netherlands: electronics and chemicals play a central role in the Dutch economy

Chemicals and electronics are among the top five most central industries in the Dutch economy in terms of their connections to other industries and the importance of these connections. Chemicals is an important buyer for many Dutch industries, while electrical equipment is an important provider of supplies for many industries. Another high-tech manufacturing sub-industry, pharmaceuticals, generates larger-than-its-size employment and income effects in other industries in the Netherlands.

Despite the heavy focus on international trade, the high-tech manufacturing industry still plays a sizable role in the domestic economy. If all of the high-tech manufacturing sub-industries were to reduce their activity by 10% in 5 years, which would be approximately equivalent to one very large company leaving the Netherlands, it would lead to a GDP loss of 2.8%. Similarly, a 10% output reduction in high-tech manufacturing would lead to an employment loss of 1.8%, equivalent to 112,000 jobs. Beyond production flows and economic effects, the high-tech manufacturing industry plays an important role in many vital economic clusters in the Netherlands.

“ Similarly, a 10% output reduction in high-tech manufacturing would lead to an employment loss of 1.8%, equivalent to 112,000 jobs ”





# The external value of the high-tech manufacturing industry

## About the interviewees: darlings, hidden champions and global leaders

This report focuses on the high-tech manufacturing industry, where some companies have a ‘darling status’, as one of the interviewees puts it, but that also includes many companies that are producing world-class products largely under the public and policy radar. These are the so-called ‘hidden champions’, highly specialised companies that are responsible for a link in international value chains and indispensable in the ecosystem that has formed around these ‘darlings’. In the slipstream of the darlings and the hidden champions, a range of smaller or medium-sized companies play their part in the ecosystems, providing elements of the high-tech products. Most of the interviewees were representing globally well-known companies.

The conventional analysis of manufacturing or the less prevalent analysis of the high-tech manufacturing industry tends to only focus on the main economic impact. However, beyond that, and perhaps more importantly, the high-tech manufacturing industry plays a crucial role in other areas. To identify these areas, we conducted about 30 interviews with members of the high-tech manufacturing industry, professional and interest organisations, government representatives and research institutions. We substantiated their statements about the value of ‘their’ industry with our analysis.

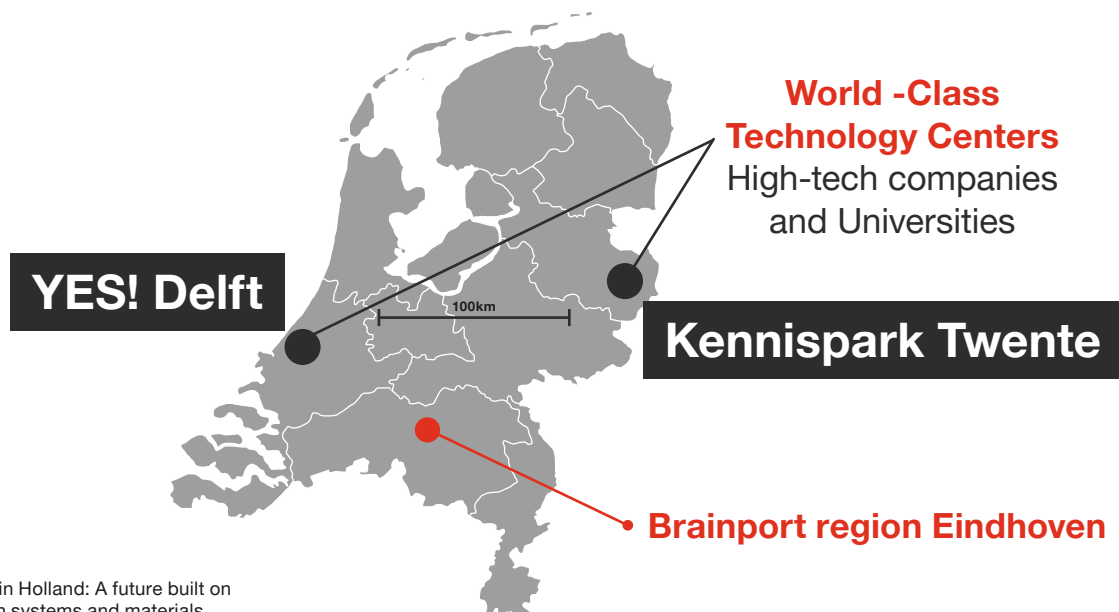
Another subject of these interviews was how we should safeguard the value of the high-tech industry. The industry itself sees its future in further developing and leveraging its unique position in global value chains. But they face a lot of challenges, such as having reliable access to electrical grid infrastructure, physical space to grow and the required labour force, which they can only solve in cooperation with the government.

### Impact on innovation, education and R&D capacity

All interviewees emphasise the importance of innovation in order to stay relevant and competitive. Especially in high-tech manufacturing branches, there is a successful record of innovation. Moreover, in this era of fast technological development, most companies cannot just rely on a one-off innovative breakthrough but rather need to continue to innovate to stay ahead of the fast-moving global technological frontier.

The dense information technology and data infrastructure of the Netherlands provides the infrastructure all these companies need. The close cooperation with universities and other knowledge institutes has generated ‘fruitful ground’ for some very promising R&D tracks. ‘The blossoming symbiosis of manufacturing and education is lifting the human capital value of the Dutch population. It is lifting the earning capacity at all skill levels beyond what would be possible without the interaction between theory and practice,’ mentioned one interviewee. ‘Education, research, and practice form a super trio,’ says another.

**Figure 3** The high-tech manufacturing is fundamental to the triple helix innovation model



Source: Invest in Holland: A future built on Dutch high tech systems and materials.

### High-tech manufacturing is a key player in innovation

In 2023, the Netherlands ranked 7th in innovation globally<sup>7</sup> and is considered an innovation leader in the EU, with the lead over other countries increasing.<sup>8</sup> Much of this success can be attributed to the public-private partnerships and collaborative ecosystems in which the high-tech manufacturing industry plays a crucial role.

This industry actively collaborates with other companies, universities and knowledge institutes, such as the Holst Centre, the Embedded Systems Institute and universities such as Delft University of Technology, Eindhoven University of Technology and the MESA+ Institute at the University of Twente (Figure 3). Many of the companies within the high-tech manufacturing industry are located or active in the high-tech industrial cluster in the south of the Netherlands. Brainport Eindhoven, which is at the heart of this cluster, is a region where knowledge institutes, start-ups, high-tech manufacturing companies and the government collaborate to foster innovation.<sup>9</sup> Hence, it is a true example of the triple helix model of innovation.<sup>10</sup>

### Education spillover effects

These close linkages with universities and research institutes, as well as high attention to educational attainment, provide employees working in the high-tech manufacturing industry with many opportunities for lifelong learning. The Netherlands has a relatively high share of foreign doctorate students, which has risen by 77.6% since 2016, despite the overall share of doctorate graduates decreasing. Many of those students end up staying in the country and working in high-tech manufacturing and other industries, boosting innovation power and productivity.<sup>11</sup> In addition, the Netherlands has raised its participation in international scientific co-publications by 74% in recent years.<sup>12</sup> This has allowed the country to not only access global markets but also gain more from global knowledge spillovers, boosting innovation capacity domestically.

### Lifelong learning is part of the high-tech manufacturing industry's competitiveness

In 2023, the Netherlands ranked 242% higher than the EU average in lifelong learning opportunities.<sup>13</sup> Manufacturing, including many high-tech manufacturing industries, is a leader in the number of employees pursuing lifelong education and having formal or informal educational attainment.<sup>14</sup> The industry is also known for the so-called 'FieldLabs', which are practical environments specialised in a wide variety of fields.<sup>15</sup> Such opportunities not only boost the skills of the employees but also the broader human capital. In addition, it is frequently heard about many ex-employees of big high-tech manufacturing companies pursuing their own entrepreneurial ambitions, starting new companies and boosting economic dynamism.

### High-tech manufacturing companies are embedded in ecosystems

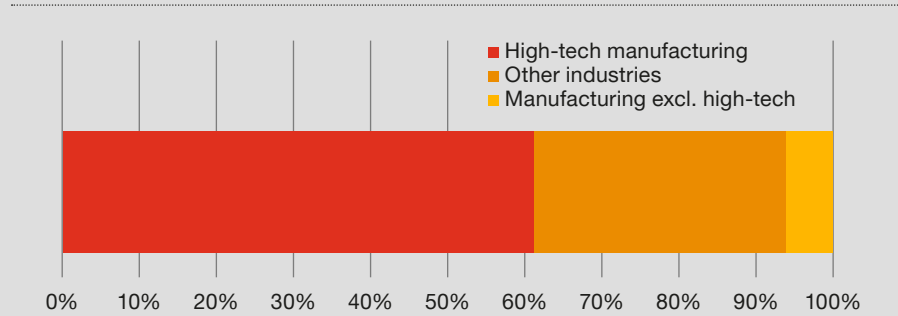
The high-tech manufacturing industry also plays a pivotal role as a linchpin in many economic connections that happen within the Netherlands, and that might not be obvious at first glance from direct production flows. Many industries and companies in the Netherlands depend on the success of the high-tech manufacturing industry. For example, it is closely interwoven with the logistics, transport, and information and communication services industries in the Netherlands.<sup>16</sup> In addition, many of the key suppliers to the leading high-tech manufacturing companies are located around the corner in the region. Hence, a network of suppliers, distributors, outsourcing companies, makers of related products and services and numerous other organisations are influenced by the development and delivery of the products of the high-tech manufacturing companies.

### Sixty-one percent of Dutch patents come from the high-tech manufacturing industry

A strong suit of the Netherlands remains technology patents. The Netherlands makes up the 4th largest number of patent applications to the European Patent Office.<sup>17</sup> The pronounced focus on knowledge-intensive industries and the intangible assets they generate, rather than the type of industries that require much space, has always been one of the main comparative advantages of the Netherlands. Key technology patents are an important indicator of future economic prosperity. It has been found that a 1% increase in key technology patents in developed economies results in an average increase of 0.1% in GDP per capita.<sup>18</sup>

If one company produces an innovation, its competitors and collaborators can gain from that. Hence, innovation does not only benefit the innovator but also the broader society. This can especially be the case for products with complex and extensive value chains. Production networks amplify the benefits of technology improvement so that long production chains facilitate faster price reduction in industries and faster GDP growth in economies.<sup>19</sup>

**Figure 4** Share of Dutch patent applications to the European Patent Office by industry in 2020

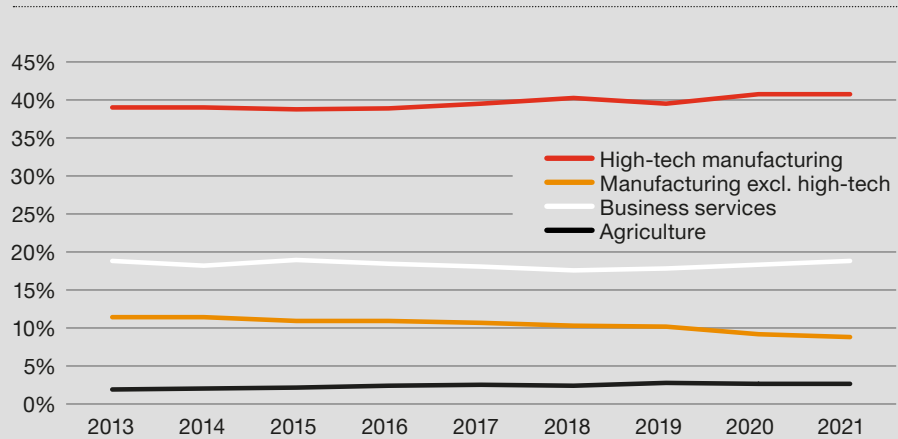


Source: CBS, PwC analysis.

### 40% of private Dutch R&D investment comes from the high-tech manufacturing industry

In addition, the high-tech manufacturing industry plays an important role in R&D spending: 40% of total private R&D investment in the Netherlands comes from it (Figure 5). Large R&D spending and high entrepreneurial activity have been found to boost the innovation climate, which is vital for economic growth.<sup>20</sup>

**Figure 5** Private R&D investment by industry in the Netherlands



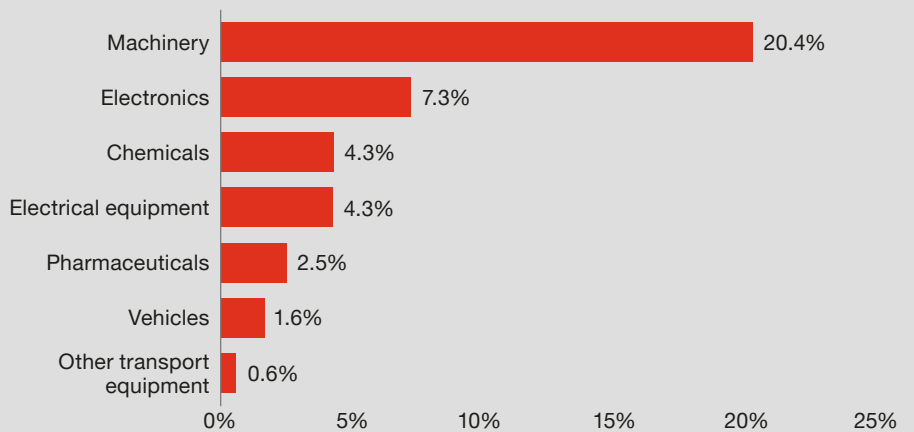
Source: CBS, OECD and PwC analysis.



### Machinery generates 20.4% of total R&D spending in the Netherlands

Within the high-tech manufacturing industry, machinery especially stands out, as it makes up around 20% of total R&D spending in the Netherlands. Other industries, such as electronics (almost 10%), chemicals and electrical equipment (both with 5%) also make up an important part of R&D spending (Figure 6).

Figure 6 Share of R&D investment by high-tech manufacturing sub-industry



Source: CBS, OECD and PwC analysis.

### Despite the high R&D spending, there is still room for improvement to make the spending more effective

For example, non-R&D innovation expenditures and sales of innovative products for the Netherlands are lagging behind.<sup>21</sup> Furthermore, medium and high-tech goods exports could be higher.<sup>22</sup> Today, the Netherlands invests around €4bn in R&D, but more than €6bn should be added to meet the Lisbon goal (3% of GDP).<sup>23</sup> This is important to not necessarily gain an advantage over other countries but to remain competitive. This would be especially important in industries where the Netherlands has strong specialisation, but where R&D spending is higher abroad.<sup>24</sup>

### Impact on megatrends

The technological pathways where Dutch manufacturing excels happen to be the ones that are geared towards addressing some of the most pressing social challenges. The energy transition and climate change, sustainable food and water provision for all, and challenges from ageing (such as declining productivity) are fields that receive input from high-tech manufacturing. This will come in handy over the coming decades, as the Dutch economy will search for sources of growth in the context of a declining labour force. Maintaining productivity growth will be vital for the competitiveness and innovation power of the Dutch economy to help both its citizens and other countries tackle the major challenges of the 21st century. We elaborate on the role of the high-tech manufacturing industry as a productivity champion on page 23).

‘You don’t solve the problems of this world only with services or trade, but with innovation and technology,’ says another. ‘It is the high-tech manufacturing industry that will come up with the answers to the major challenges of our time, such as climate change, adequate, sustainable, healthy and just food supply, solutions to the world’s diseases, or effective care for an ageing population.’

### Impact on competitiveness and resilience

‘Can a modern country prosper without a high-tech manufacturing industry?’ That is the counter-question that many respondents raise when we ask about its importance. The high-tech manufacturing industry contributes to the resilience of a country or region and makes it less dependent on production assets in foreign countries.

Having a mature manufacturing industry capable of producing critical goods on your soil makes a country’s economy and society more resilient against shocks. The Covid-19 pandemic is a recent example. One of the companies we talked to referred to the ability to produce crucial commodities in times of need as ‘an extremely helpful insurance policy’. The Netherlands is well positioned to take on such insurance. In fact, this effect may have contributed to the Netherlands’ relatively smaller economic dip and faster recovery after the Covid-19 pandemic, compared with Germany and the UK.

### Impact on the quality of the environment, war for talent and competing for space

The high-tech manufacturing industry’s activities could have an impact on the quality of the environment. Manufacturing competes heavily with the broader society for space, accounting for around 20% of all the built-up areas in the

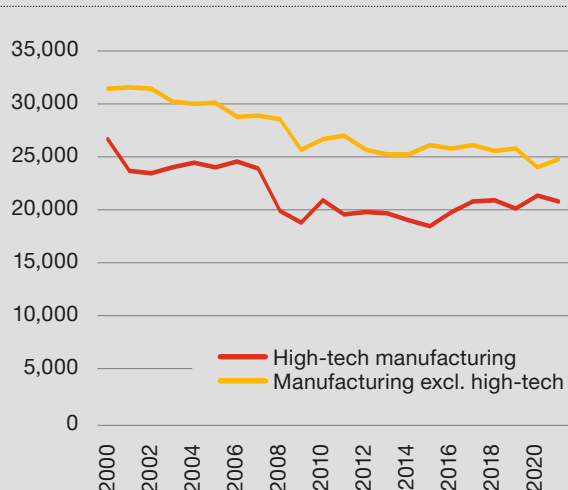
Netherlands. The actual figure is almost certainly higher when accounting for indirect factors such as additional housing for employees, space for infrastructure like energy and data connections, as well as transport and traffic. The negative external effects and the competition for the environment, space and resources are clearly observed and felt by the greater public. The consequences of the negative effects are reflected in the mood of society towards the manufacturing sector.

An important notion of the high-tech manufacturing industry and a consequence of the megatrends is that growth is imperative for the ecosystem. One of the interviewees said, ‘every innovation done in the mentioned fields needs to rapidly scale up to capture the goldilocks position on the value chains, so growth is an automatic undercurrent. This means that competition for space is permanent.’

### The green transition poses challenges and opportunities for high-tech manufacturing

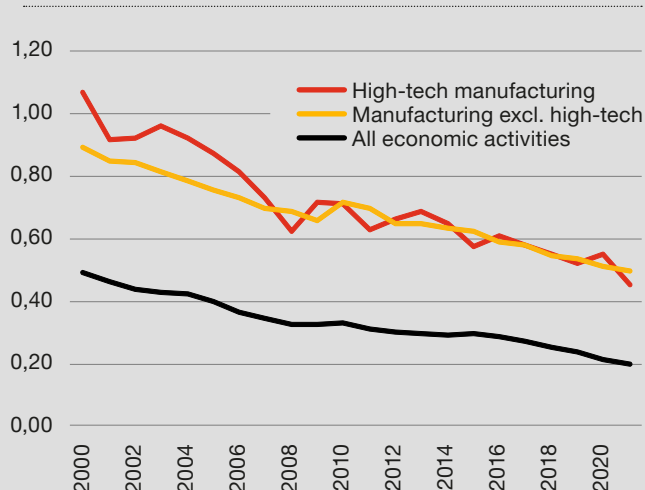
When it comes to total greenhouse gas emissions (GHG), the high-tech manufacturing industry has not been decarbonising fast enough, although there has been a slight improvement in the past two decades (Figure 7). In addition, the Dutch high-tech manufacturing industry is the most emissions-intensive among other countries compared.<sup>25</sup>

**Figure 7** Dutch greenhouse gas emissions in millions of kg by kind of manufacturing



Source: CBS, OECD and PwC analysis.

**Figure 8** GHG intensity (kg of GHG per euro gross value added) by kind of manufacturing



Source: Eurostat and PwC analysis.

### Nevertheless, GHG intensity for the high-tech manufacturing industry has been declining

On the other hand, GHG intensity for the high-tech manufacturing industry, as well as the rest of manufacturing, has been on the decline since 2000 (Figure 8). The GHG intensity has declined faster than emissions as the industry has been growing in the meantime, therefore still having a similar amount of total emissions while being more energy efficient. From the GHG intensity point of view, the chemicals industry stands out.<sup>26</sup> It historically has had a much higher GHG intensity, and although it has declined significantly in the past two decades, it is still above that for other high-tech manufacturing industries.

The recent energy crisis has exposed vulnerabilities. High-tech manufacturing industry is facing a difficult journey to decarbonise, requiring even larger structural investments. To accelerate sustainability in the industry and the broader economy, a joint system approach by companies, knowledge institutions and government with a focus on innovation and R&D will be imperative.<sup>27</sup>

### The green transition also presents an opportunity for the high-tech manufacturing industry

High-tech manufacturing already plays and will play an essential role in the green transition. The Netherlands has almost tripled its production capacity for renewable energy since 2015.<sup>28</sup> Although the clean-tech industry in the Netherlands is not one of the strongest in the country yet and ranks similar to other EU countries<sup>29</sup>, it produces most devices that are and will be needed to decarbonize, such as solar panels, wind turbines and their sub-components. Even if imports of such technology will also play an important role, more and more countries are realising that to achieve their green transition goals, a significant share of domestic production capacity will also be needed.

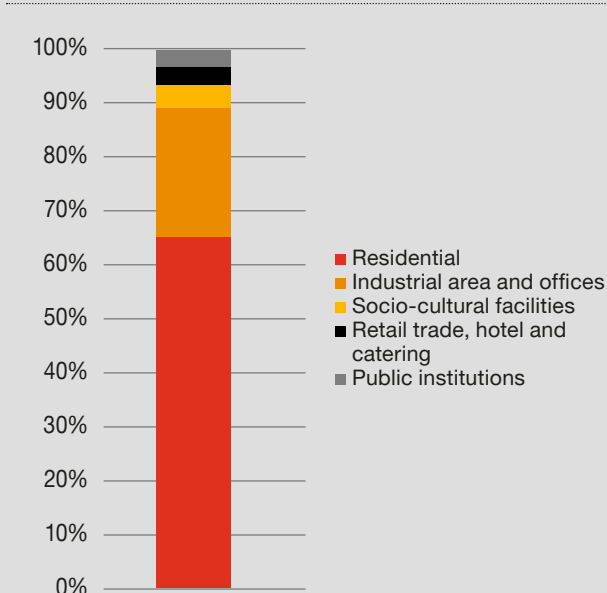
### Green jobs will boost the appeal of the high-tech manufacturing industry

To ramp up production, high-tech manufacturing companies working in the growing clean-tech sector will require labour inputs, the so-called 'green jobs'. Researchers concluded that jobs in the production, installation, maintenance and distribution of green technologies have a 21% wage premium relative to the average. In addition, the pay premium is even higher for low- and middle-skilled workers, as they could earn 30% more than average.<sup>30</sup> This means that green jobs in such companies can be more attractive than similar roles in legacy industries, therefore incentivising people to consider career shifts. However, that could also exacerbate the ongoing war for talent if labour supply does not increase sufficiently.

### It is unclear to what extent the high-tech manufacturing industry is behind the space and housing problems

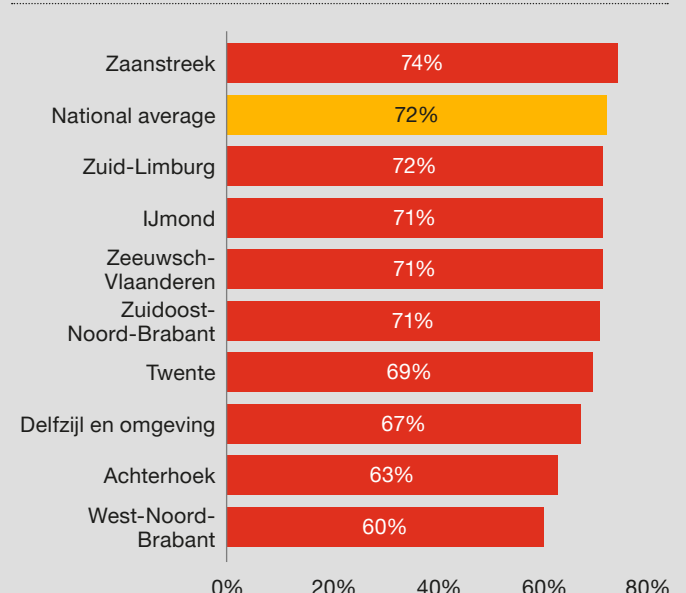
There are important concerns about the effect of high-tech manufacturing on the housing market of host communities. For example, the average house price in Noord-Brabant has increased by 62% (Figure 10). In some areas, like Eindhoven and Veldhoven, the figure lies at 71%. Citizens argue that the presence of high-tech manufacturing giants is responsible: as these firms invest and grow, they consume more space for both their operations and their well-paid (expat) workers. However, the data does not entirely support that conclusion. On the one hand, manufacturing, including high-tech manufacturing, is a land-intensive industry. Figure 9 shows that industrial areas and offices account for around 20% of the built-up area in the Netherlands, even though high-tech manufacturing employs 4% of the labour force (manufacturing less than 10%).

**Figure 9** Percentage share of total built up area by building purpose in 2017



Source: CBS and PwC analysis.

**Figure 10** Percentage change in house prices in manufacturing hubs since 2010



Source: CBS and PwC analysis.

On the other hand, it is not true that high-tech manufacturing is the sole driver of ballooning house prices. As depicted in Figure 10, most of the high-tech manufacturing hubs have seen house prices increase below or in line with the national average of 72%. Furthermore, our analysis indicates that there is no significant relationship between manufacturing investment and house prices within these clusters. This is because high-tech manufacturing, on average, does not require plenty of workers since it is a capital-intensive process. However, very large companies, such as ASML, are, of course, exceptions to this, despite being capital-intensive, still requiring many employees.

While housing in high-tech hubs is a matter of genuine concern, non-manufacturing regions also experience a similar plight. Thus, this market failure is a national rather than local problem; it does not distinguish between industries. Furthermore, it is likely that the pressure on housing and public space in certain specific areas, such as Veldhoven, the headquarters of ASML, is higher than where the other high-tech manufacturing companies are located. ASML has also recently engaged with the local government to build social housing not for its employees but the residents of the city that are impacted by the growth of the company.<sup>31</sup> The company expects to hire tens of thousands of additional employees in the coming years to meet the growing demand in the chip industry. This requires knowledge migrants and additional housing to accommodate them. ASML contributes to housing projects, but if it can no longer grow in the Netherlands, it will do so abroad.<sup>32</sup>

### How to preserve the value of the high-tech industry?

Without exception, all parties share the conviction that the high-tech sector is essential for the Netherlands, not only for the economy but also for society more broadly. And for that, they also share the view that the industry deserves more credit and recognition than it currently receives. The principle that, in our modern society, industry and government need to play their respective roles effectively and in some form of harmony is considered self-evident. This interplay, or tango, clearly involves addressing dilemmas and striking policy decisions where interests may not be fully aligned. And because decisions and actions have longer-term consequences for behaviour, innovation and investment, a coherent, longer-term vision of what sort of industry the Netherlands' society would benefit most from is currently lacking.

### Focus on a unique position in value chains

Many of the parties that we spoke to concluded that the Netherlands should focus on acquiring a unique position in European value chains, as it would lead to more geopolitical leverage. 'The major societal transitions lead to new value chains. The Netherlands should take a position in a way that cannot be ignored. It's about unique positions in the value chain, not about establishing the entire value chain in the Netherlands.'

The government and the business sector must work together to achieve this. 'Putting up a fence' around the Netherlands is a bad idea, according to all the conversation partners. Actions by other countries, such as the American Inflation Reduction Act, have emphasised the importance of a well-functioning European economy.

### A clear vision on high-tech manufacturing industry policy

The interviewees indicate that the high-tech manufacturing industry needs a political vision: what kind of country do we want to be, and what kind of economy and industry should go along with it? If agriculture needs to shrink, what will we use the freed-up land for? If industrial policy is no longer a dirty word, which industry will we pursue with that policy? Which industry has the greatest economic and societal added value? 'For example, how do we want to distribute land in the Netherlands? The government has not formed a new idea about that since the eighties,' says a representative of the business community.





# The main economic indicators of the high-tech manufacturing industry

## The economic size of high-tech manufacturing

In the Netherlands, services have become a much bigger part of the economy, at the expense of manufacturing and agriculture. The high-tech manufacturing industry makes up around 6% of Dutch GDP, of which 2% comes from machinery. Other sub-industries, except chemicals, make up less than 0.6% each. This share has remained relatively stable over time, unlike in other countries (except for Germany). Moreover, the Dutch high-tech manufacturing industry has fared much better than the rest of manufacturing, maintaining its relative economic size and gaining importance within the broader manufacturing sector.

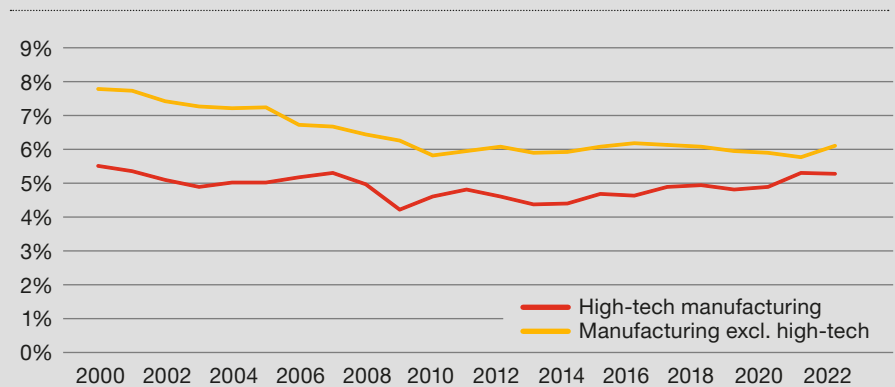
### Points to ponder:

- *Should the high-tech manufacturing industry sector grow with an eye on resilience?*
- *Should the government play an active role in that?*

**Compared to other industries, high-tech manufacturing is a small part of the economy**

Since 2000, on average, the high-tech manufacturing industry has accounted for around 6% of GDP (Figure 11). However, unlike the rest of manufacturing, which has lost its GDP share at a faster pace, the high-tech manufacturing industry's share has remained intact. Hence, it has gained relative economic size within the broader manufacturing sector.

**Figure 11** Share of the Dutch GDP by kind of manufacturing

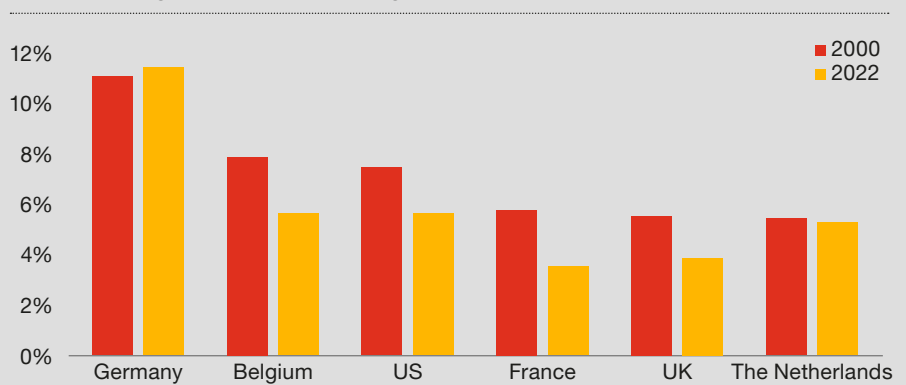


Source: OECD, PwC analysis.

**The high-tech manufacturing industry in the Netherlands has kept its economic size better than in other countries (excl. Germany)**

In addition, compared to other countries, the Dutch and German high-tech manufacturing industries stand out as having kept a stable share of the GDP (Figure 12).

**Figure 12** High-tech manufacturing share of GDP

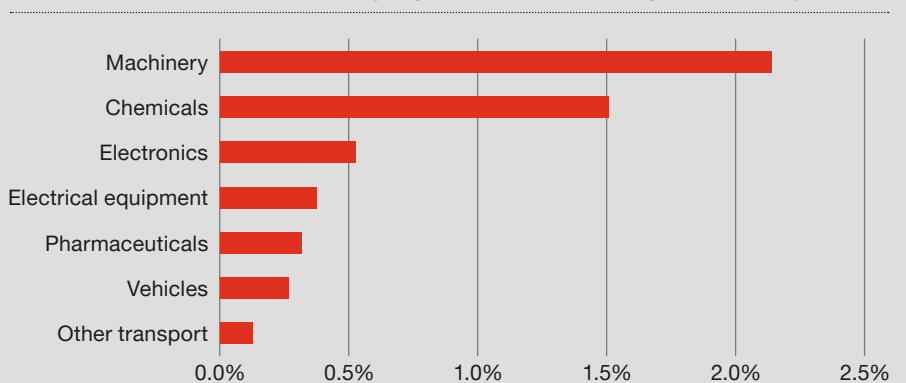


Source: OECD, PwC analysis.

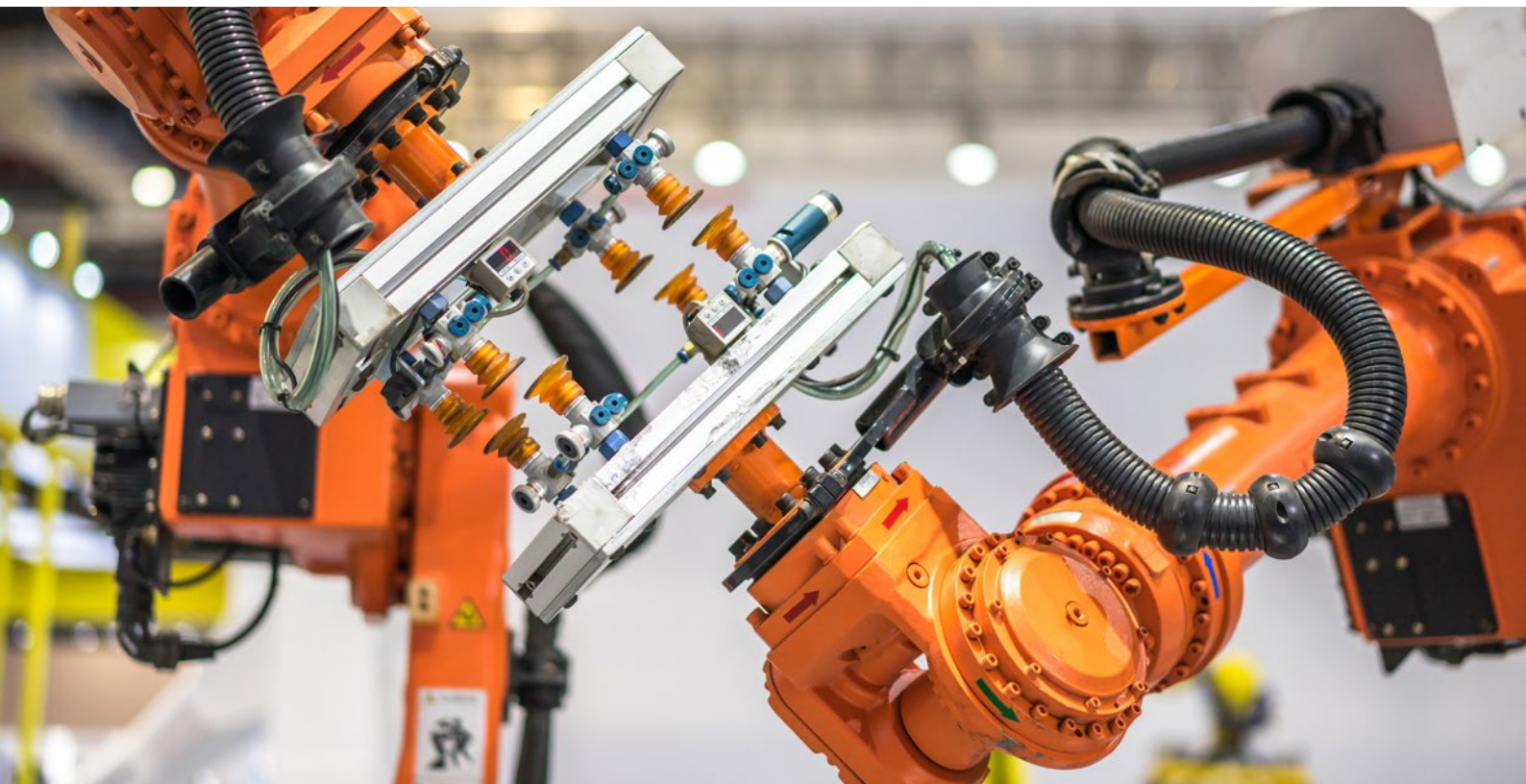
**Machinery is the largest of the high-tech manufacturing sub-industries**

Within high-tech manufacturing, the machinery industry accounts for most of GDP, around 2%. The GDP of all other industries is less than 0.6%, except for chemicals (Figure 13).

**Figure 13** Share of Dutch GDP by high-tech manufacturing sub-industry



Source: OECD, the World Bank, PwC analysis.



## Jobs and wages in the high-tech manufacturing industry

The high-tech manufacturing industry is not a 'jobs machine': it makes up less than 4% of total employment in the Netherlands, which is also less than in other countries. Over the past two decades, the high-tech manufacturing employment share has remained more stable than for the rest of manufacturing. The 'biggest' employers within this industry, namely machinery and chemicals, are still small compared to other industries. None of the high-tech manufacturing sub-industries make up even 1% of total employment in the Netherlands.

As in the rest of the economy, the high-tech manufacturing industry is experiencing significant labour shortages. In all sub-industries, at least 25% of companies mention labour shortages as a concern (an exception is chemicals). Even though small from the employment side, the jobs within the Dutch high-tech manufacturing industry pay on average 50% more than in services. It is unclear whether further pay increases would help alleviate the labour shortages in the industry.

Hence, it is not a 'jobs machine', but the relatively few jobs it creates are well paid. As labour shortages are expected to persist in the future, this is a sign for the industry that, rather than creating many jobs, it can focus on fewer but better-paid jobs. However, there is still significant effort to be done to increase its attractiveness in the eyes of students and foreign workers.

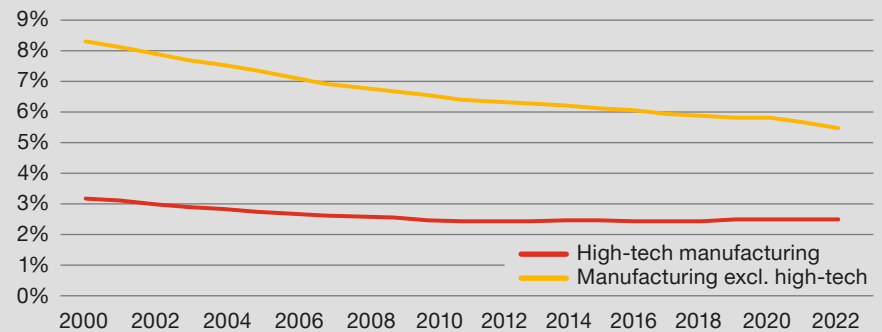
### Points to ponder:

- *What role should companies and governments play in attracting workers, especially young talent, to the industry?*
- *What recipes are there for dealing with labour shortages?*

**The high-tech manufacturing industry is not a 'job machine', with less than 4% of total employees**

From Figure 14, it can be seen that high-tech manufacturing companies have historically employed less than 4% of the total workforce. However, this share has remained more stable than for the rest of manufacturing.

**Figure 14** Share of total employment in the Netherlands by kind of manufacturing

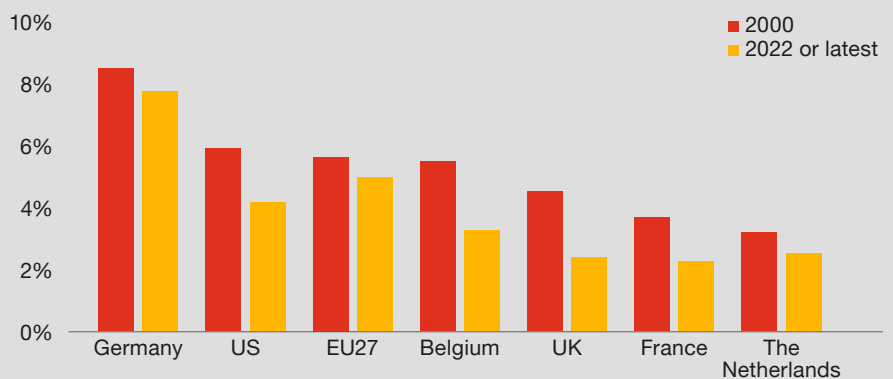


Source: Eurostat, PwC analysis.

**The employment share of the high-tech manufacturing industry has decreased in several countries**

When comparing internationally, the high-tech manufacturing industry has experienced a slight decline in employment in the past 22 years, although the Dutch and German industries have had a more stable employment rate than the same industry in other countries (Figure 15).

**Figure 15** High-tech manufacturing share of employment



Source: Eurostat, PwC analysis.

“ The employment share of high-tech manufacturing has remained more stable than for the rest of manufacturing.

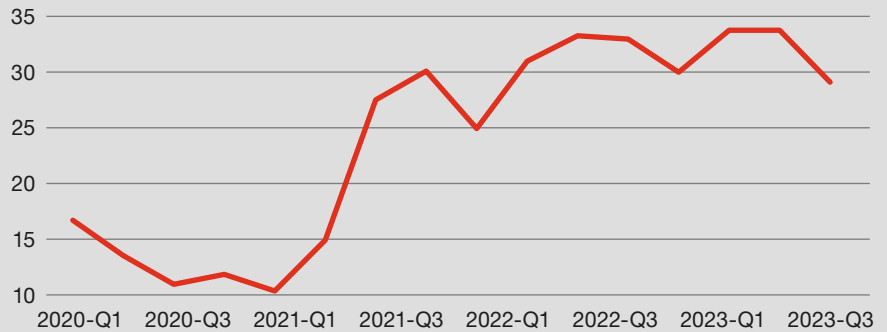


**Up to 25% of high-tech manufacturing companies report labour shortages**

Although a relatively small employer within the Netherlands, the high-tech manufacturing industry also struggles to find enough workers. Since 2021-Q3, almost 30% of companies have been indicating that labour shortages are an important bottleneck to production. However, this number has been declining recently while still remaining elevated compared to pre-Covid-19 (Figure 16).

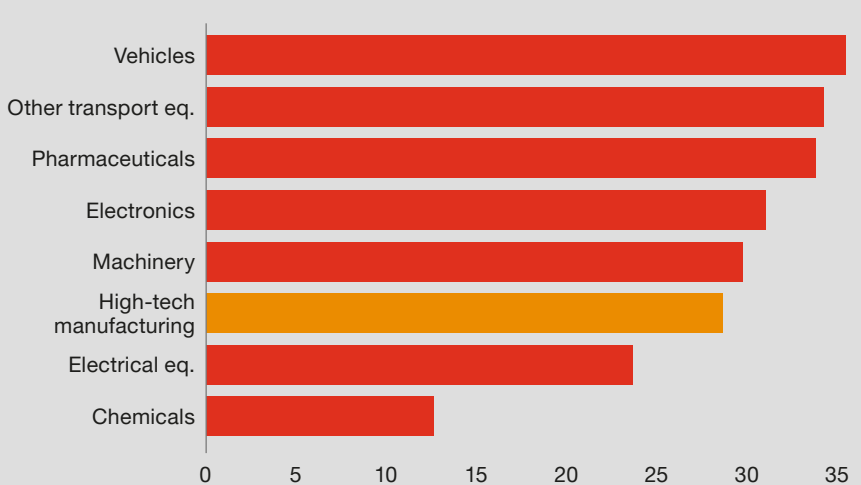
Among the high-tech manufacturing sub-industries, the highest share of companies reporting labour shortages in 2023-Q4 are in vehicles, other transport equipment and pharmaceuticals, where more than 30% of companies experienced labour shortages. The lowest share is in chemicals, with less than 15% of companies reporting labour shortages, which is substantially lower than the other high-tech manufacturing sub-industries (Figure 17).

**Figure 16** Share of high-tech manufacturing companies reporting labour shortages



Source: European Commission business and consumer surveys, PwC analysis.

**Figure 17** Share of companies reporting labour shortages in 2023-Q4 (seasonally adjusted)



Source: European Commission business and consumer surveys, PwC analysis.

The acute labour shortages present challenges to the industry. It is anticipated that in the coming years, there will be increasing bottlenecks in the supply of personnel for secondary vocational education (MBO) graduates because most of the retiring labour force is MBO-educated.<sup>33</sup> This will especially concern occupations such as engineering, which are prevalent in the high-tech manufacturing industry. To solve the shortage of technicians, for example, personnel are already being recruited abroad, and many foreign students with degrees in engineering continue to work in the Netherlands after their studies. However, effort should also be put into engaging more Dutch youth in technical studies<sup>34</sup> and attracting more knowledge migrants to the high-tech manufacturing industry.<sup>35</sup>

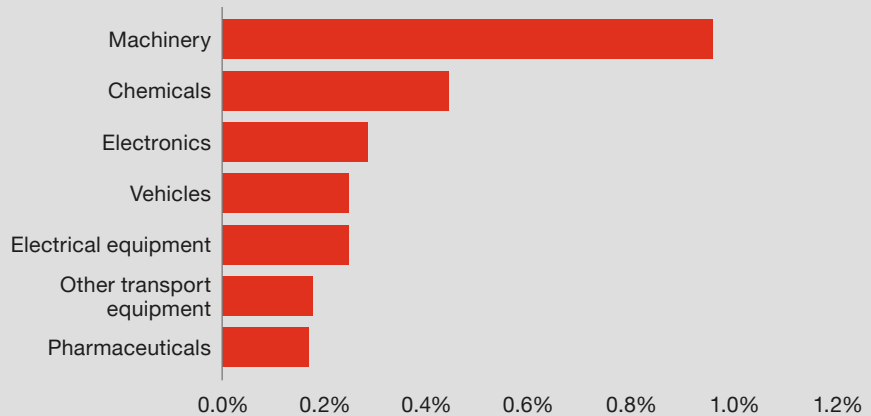
### The largest high-tech manufacturing employers are machinery and chemicals

Even the biggest employer, the machinery industry, barely reaches 1% of total employment (Figure 18).

### The high-tech manufacturing industry pays 50% more per hour than the rest of the economy

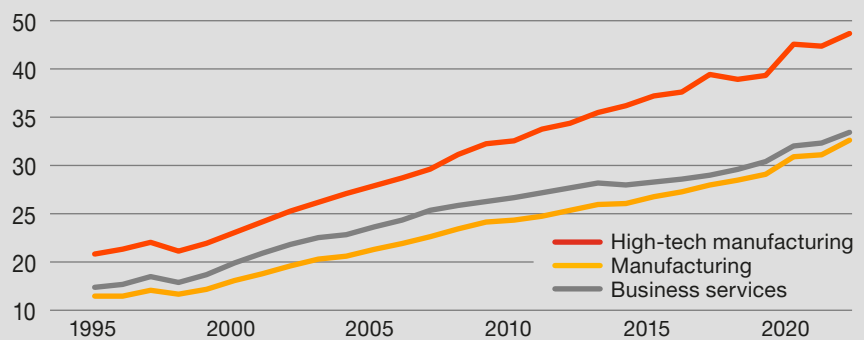
The high-tech manufacturing industry pays only 4.59% of the total employee compensation in the Netherlands. This approximately aligns with the industry share of total jobs in the economy (less than 4%). However, when it comes to employee compensation per hour worked, the high-tech manufacturing industry sector has been paying up to 50% more than manufacturing and services. In 2023, this amounts to around €45 per hour worked, while in the rest of the economy it is around €30 (Figure 19). Furthermore, the difference has been growing since 2000, when average wages were only around €5 larger in the high-tech manufacturing industry than elsewhere.

Figure 18 Employment share of high-tech manufacturing sub-industries in 2022



Source: Eurostat, PwC analysis.

Figure 19 Dutch employee wages per hour worked in euro by industry



Source: CBS, PwC analysis.



Even though small from the employment side, the jobs within the Dutch high-tech manufacturing industry pay on average 50% more than in services.



## Productivity of the high-tech manufacturing industry

The high-tech manufacturing industry is a 'productivity champion': it is four times more productive than services and twice as productive as the rest of the manufacturing industry. This industry has almost doubled its gross value added per employee, from more than €100,000 in 2000 to more than €187,000 in 2022. Moreover, the Dutch high-tech manufacturing industry is an international leader in productivity, exceeding the gross value added per employee in all other countries compared. Since 2000, all high-tech manufacturing sub-industries have raised their productivity by at least 87%, with chemicals and machinery exceeding 200%. The only outlier is the electronics industry, whose productivity growth has stagnated. Chemicals now make more than €1000 in output per hour worked, while in other high-tech manufacturing industries it is less than €400.

### Points to ponder:

- *What should the high-tech manufacturing industry and the government do to maintain the productivity of the industry?*
- *Could the high-tech manufacturing industry contribute to the productivity increase of all industries in the Netherlands?*

**The productivity of the high-tech manufacturing industry is four times higher than services**

One of the main takeaways when looking at the high-tech manufacturing industry is that its labour productivity is almost four times higher than for services and twice that of the rest of manufacturing (Figure 20), generating more than €400 of output per hour worked. The share of gross value added per employee within the Dutch high-tech manufacturing industry has steadily grown since 2000, almost doubling in that time period.<sup>36</sup>

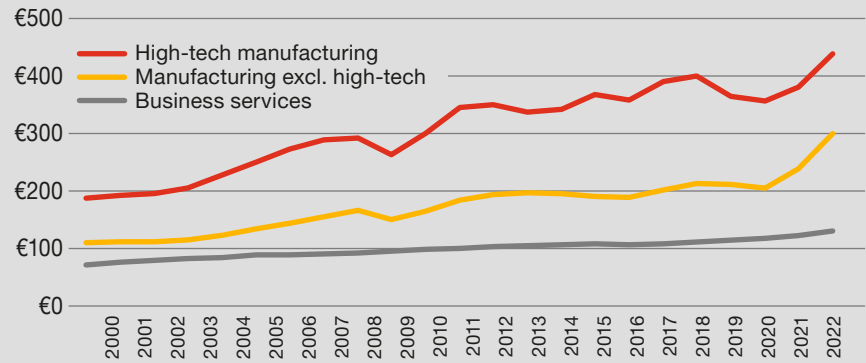
**The Dutch high-tech manufacturing industry is an international productivity leader**

When looking at other countries, the Dutch high-tech manufacturing industry stands out. It produces €187,833 per employee, which is more than the other countries considered, including the United States (Figure 21).

**Chemicals, machinery and other transport equipment are the most productive among the high-tech manufacturing sub-industries**

Labour productivity has increased in almost all high-tech manufacturing sub-industries since 2000, with chemicals and machinery increasing their labour productivity by more than 200% during this period (Figure 22). In 2022, chemicals is the most productive high-tech manufacturing industry, with more than €1000 of output per hour worked. For other high-tech manufacturing sub-industries this is around €300 per hour worked, while for services less, it is than €200.<sup>38</sup>

**Figure 20** Labour productivity (output per hour worked) by industry



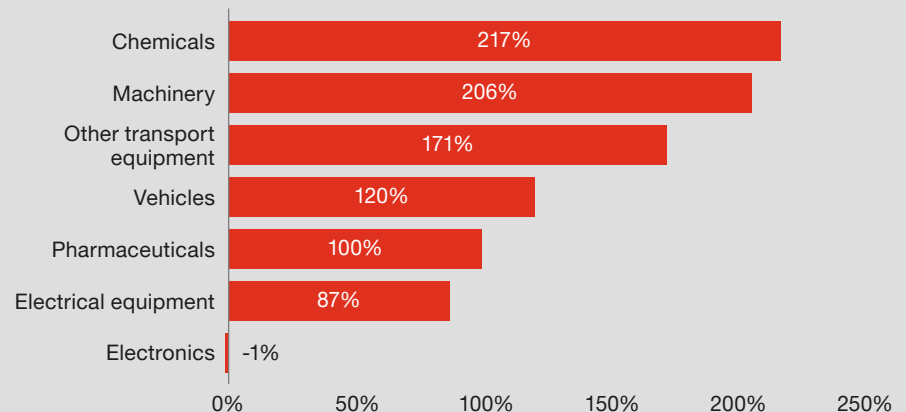
Source: OECD, PwC analysis.

**Figure 21** Gross value added per employee in high-tech manufacturing



Source: OECD, PwC analysis.

**Figure 22** Percentage change in labour productivity since 2000 for high-tech manufacturing sub-industries



Source: OECD, PwC analysis.



### Electronics stands out among the high-tech manufacturing sub-industries with stagnating labour productivity

Unlike the rest of high-tech manufacturing, output per hour in the Dutch electronics industry's labour productivity has decreased by 1% since 2000. This is due to a decline in revenue rather than an increase in the number of hours worked, which in turn seems to be caused by lower prices rather than volume.<sup>39, 40, 41</sup>

Cross-country comparisons show that this is a uniquely Dutch phenomenon, as other countries with a strong electronics industry, such as Germany and the US, did not experience the same issue.<sup>42</sup>

### For an economy to fully benefit from productivity, it has to spread widely

Because an industry's success in innovation depends on complementary innovations among its input suppliers, rapid productivity growth that is concentrated in a subset of sectors may create bottlenecks and consequently fail to translate into aggregate productivity gains. Indeed, Acemoglu et al. (2023) found that a substantial part of the US productivity slowdown, including that of other industrialised countries, among them the Netherlands, can be accounted for by productivity growth differences between industries.<sup>37</sup> In the Netherlands, this productivity bottleneck effect reduced productivity growth by almost 60% from 1992 to 2007. Hence, for companies in the high-tech manufacturing industry, which are productivity champions, it might be prudent to focus on making sure that their productivity gains translate to their suppliers, customers, and other industries.

### Profitability of the high-tech manufacturing industry

High-tech manufacturing has been one of the leading industries within the Netherlands for the past two decades, exceeding the average profit and sales growth of 57%. The high-tech manufacturing industry has higher than average operating margins, but companies such as ASML make up a disproportionate share of that. Pharmaceuticals, machinery and chemicals have higher operating margins than the rest of the high-tech manufacturing industry.

#### Points to ponder:

- *What actions should the companies in the high-tech manufacturing industry take to retain their profitability?*
- *What impact will trends such as labour shortages, rising geopolitical tensions and climate change have on the 'bottom-line' of high-tech manufacturing companies?*

**High-tech manufacturing industry leaders, such as ASML, are pulling ahead of the rest of the industry**

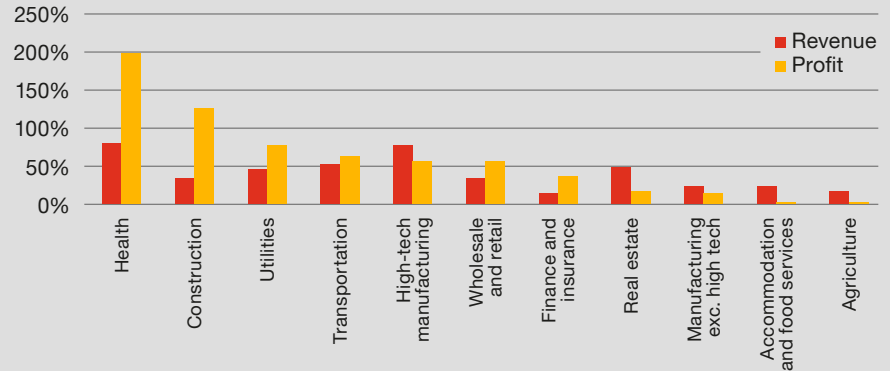
Dutch high-tech manufacturing companies have fared well in the last two decades, exceeding the average profit and sales growth of 57% in the economy compared to other manufacturing industries (Figure 23).

However, it could be mainly driven by industry leaders such as ASML, which have vastly exceeded the average operating margins of the high-tech manufacturing industry. In addition, when looking at the last decade for most industry leaders as well as the high-tech manufacturing average, operating margins have stagnated (Figure 24).

**Potential profitability headwinds of high-tech manufacturing industry**

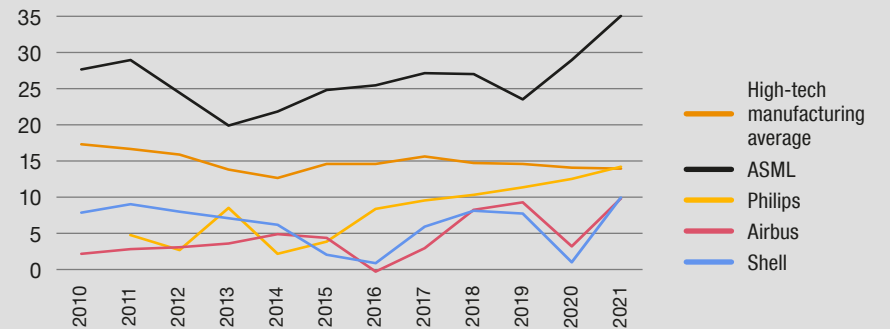
This trend presents a challenge to the industry. Although industries such as pharmaceuticals, machinery and chemicals have high operating margins, exceeding 10%, the rest of the high-tech manufacturing industry has significantly lower operating margins (Figure 25). Hence, looking forward, the profitability of the industry is under pressure, given increasing labour shortages, building restrictions and challenges to the infrastructure.

**Figure 23** Growth in revenue and profits since 2000



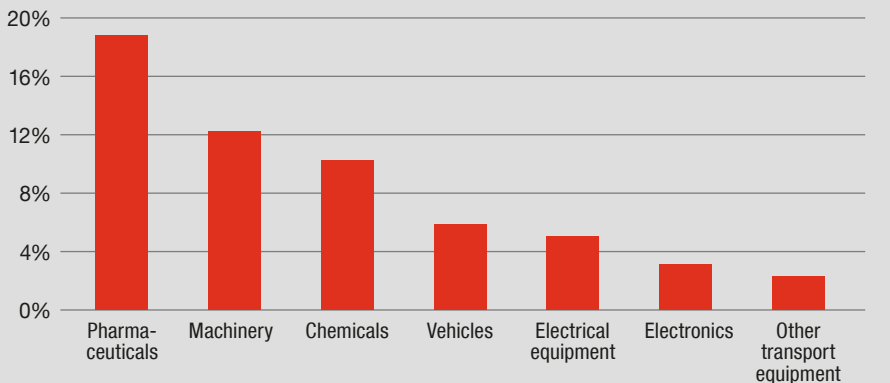
Source: S&P, PwC analysis.

**Figure 24** Operating margin in high-tech manufacturing and companies in the industry



Source: S&P, Factiva, ASML, PwC analysis.

**Figure 25** Net operating margin in 2022 per high-tech manufacturing sub-industry



Source: S&P, PwC analysis.



## The role of domestic and foreign investment in the high-tech manufacturing industry

High-tech manufacturing makes up around 6% of capital expenditures in the Netherlands, with the biggest investment drivers being machinery (2.5%) and chemicals (almost 2%). It invests relatively more than the rest of manufacturing, but, unlike labour productivity, its share lags behind the high-tech manufacturing industry in other countries. In addition, foreign investors have been steadily exiting the industry, similar to elsewhere. The foreign-owned Dutch high-tech manufacturing companies remaining are few, but important.

### Points to ponder:

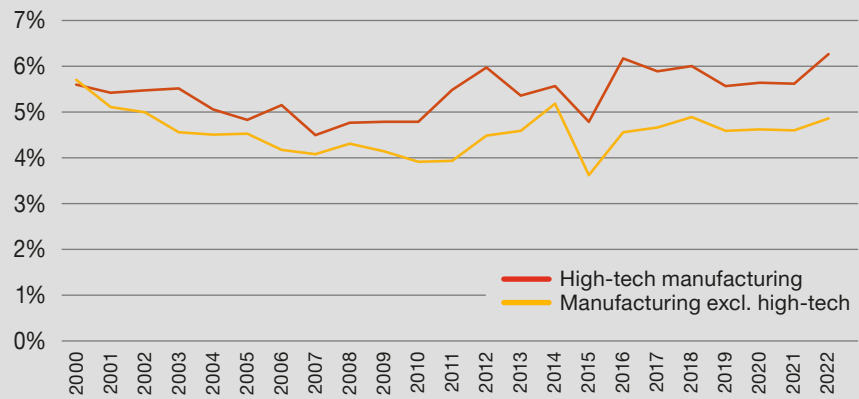
- *How come the high-tech manufacturing industry is an international leader in labour productivity but not in investment?*
- *What are the factors, if any, hindering investment in the high-tech manufacturing industry?*

**The high-tech manufacturing industry makes up a small part of overall Dutch business capital expenditures and lags other countries**

The high-tech manufacturing industry generates around 6% of Dutch business capital expenditures (Figure 26). Even though this share is slightly higher than for the rest of manufacturing, it remains a relatively small share of the total in the Netherlands.

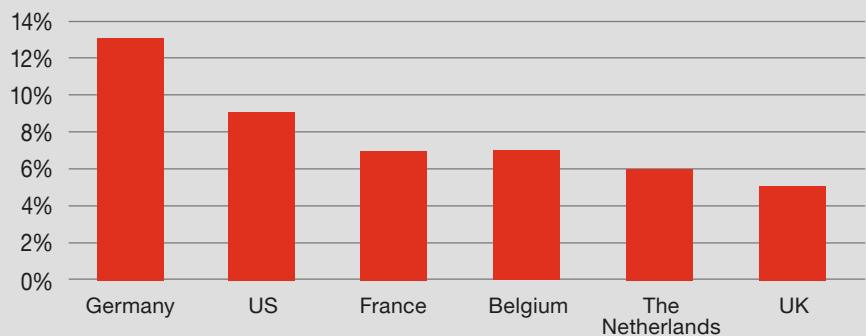
When compared to other countries, the Dutch high-tech manufacturing industry, with around 6% of total capital expenditures, lags behind Germany, the United States, France and Belgium (Figure 27). However, this could be because the Netherlands focuses on a very specific yet valuable part of the high-tech manufacturing supply chain. In addition, as this is a relative cross-country comparison, it is difficult to exactly pinpoint the reason behind this difference. It could depend on how relatively capital-intensive other industries are, both in the Netherlands and in other countries.

**Figure 26** Percentage share of capital expenditures in the Netherlands by industry



Source: S&P, PwC analysis.

**Figure 27** High-tech manufacturing's share of total capital expenditures by country



Source: S&P, PwC analysis.

**The availability of public money could partially explain the investment gap**

The Netherlands and the EU offer several public instruments to boost investment and R&D. Locally, there are financing means available through the WBSO tax credit for research and development as part of the innovation box<sup>43</sup> and the National Growth Fund, totaling €20bn spending from 2021 to 2025.<sup>44</sup> At the EU level, the European Commission loosened state aid rules in the wake of Russia's full-scale invasion of Ukraine last year to help European businesses cope with a surge in inflation fuelled by high energy prices and to promote the green transition.<sup>45</sup> It also has several subsidies available through its Green Deal Industrial Plan.<sup>46</sup> In addition, not only subsidies but other fiscal measures and higher use of the capital markets could be beneficial. For example, in the US, 75% of financing happens through capital markets, while in the EU, it is the opposite: 80% of financing comes from banks.<sup>47</sup>

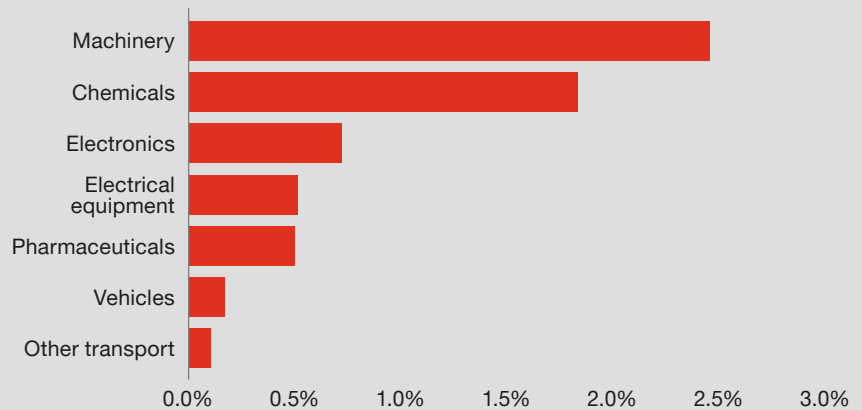
In this report, we do not, however, assess the degree of usage or effectiveness of these public financing schemes. It could be that the more generous local public financing investments available in the Netherlands compared to other countries explain the relative investment gap. However, it is unlikely that the Dutch public investment instruments are more generous and effective than elsewhere.<sup>48</sup> The EU-level subsidies would not be part of the explanation as they are available to all EU member states.



### Machinery and chemicals are drivers of capital expenditures

Leaders within the high-tech manufacturing industry are machinery and chemicals, which account for over 2% of capital expenditures in the Netherlands (Figure 28).

**Figure 28** Percentage share of capital expenditures in the Netherlands by sub-industry

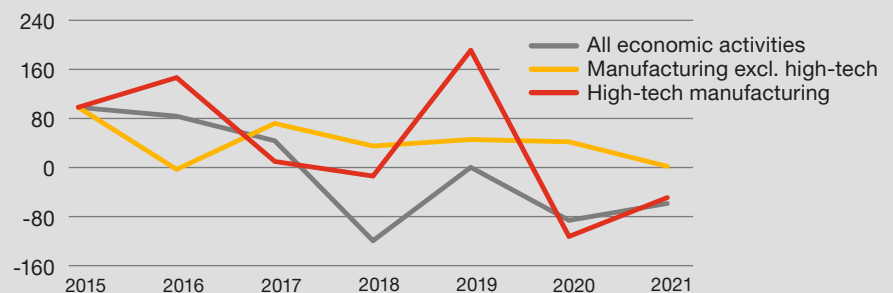


Source: S&P, PwC analysis.

### International investors are exiting the Dutch high-tech manufacturing industry

The Netherlands has experienced a decline in inward foreign direct investment (FDI) flows since 2015 in all economic activities, including high-tech and other manufacturing (Figure 29). High-tech manufacturing was faring better until the Covid-19 pandemic, when its FDI plummeted. The inward FDI flows have been recovering since then but are still below 2015 levels.

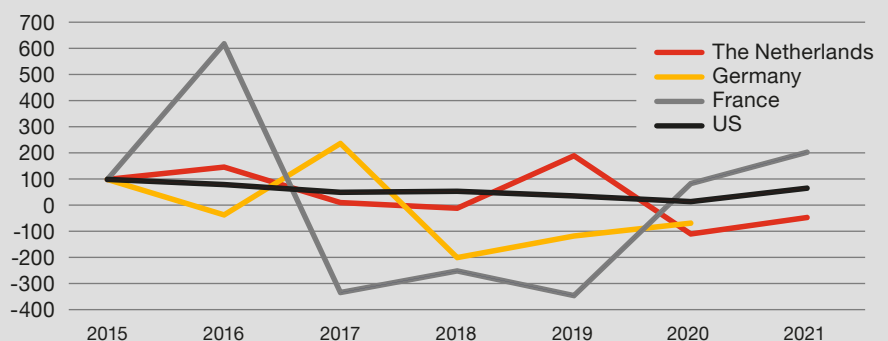
**Figure 29** Foreign direct investment flows into the Netherlands by industry (2015 = 100)



Source: CBS, PwC analysis.

However, the Netherlands is not an outlier compared to other countries, which have experienced inward FDI declines since 2015 (Figure 30). Hence, as international investors are looking more and more globally, not only the Netherlands but the EU are losing out.<sup>49</sup>

**Figure 30** FDI flows into high-tech manufacturing\* by country (2015 = 100)

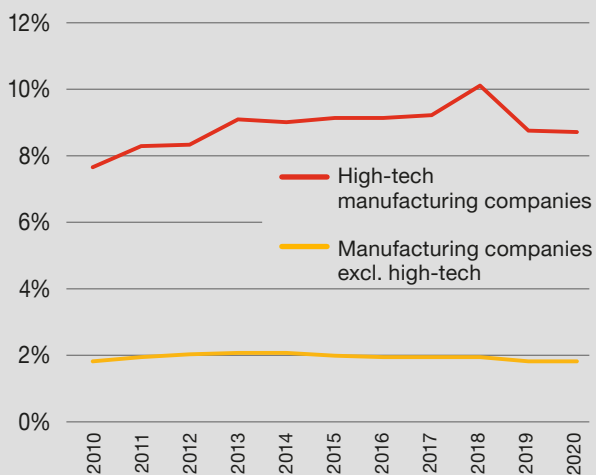


Source: OECD, PwC analysis. \*Excludes industry C27 Electrical Equipment due to data unavailability.



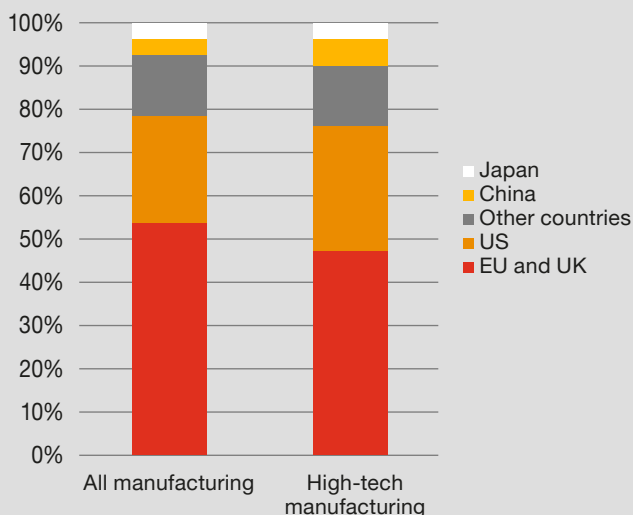
There are few large and important foreign-owned high-tech manufacturing companies

**Figure 31** Share of foreign-owned companies by type of manufacturing



Source: CBS, PwC analysis.

**Figure 32** Foreign-owned manufacturing companies by country

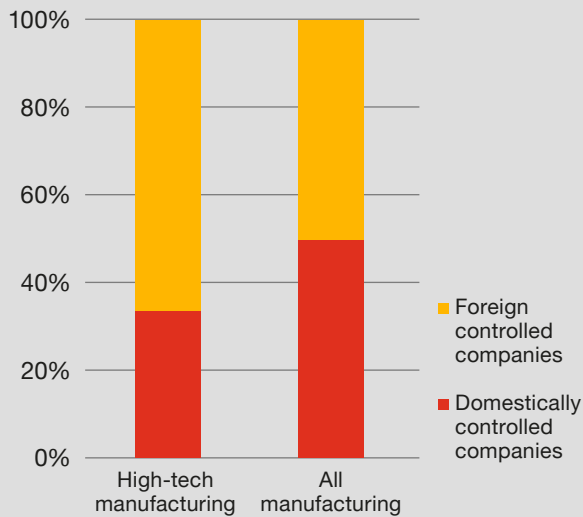


Source: CBS, PwC analysis.

At first sight, foreign-owned firms<sup>50</sup> make up only around 9% of Dutch high-tech manufacturing companies. This share has only moderately increased since 2010 (Figure 31). Most of the foreign-owned high-tech manufacturing companies are either controlled by companies in other EU member states, in the UK or in the US. This trend is similar to the broader manufacturing industry (Figure 32). However, foreign-controlled high-tech manufacturing firms accounted for 66% of revenue (Figure 33) and almost 30% of R&D expenditure (Figure 34).

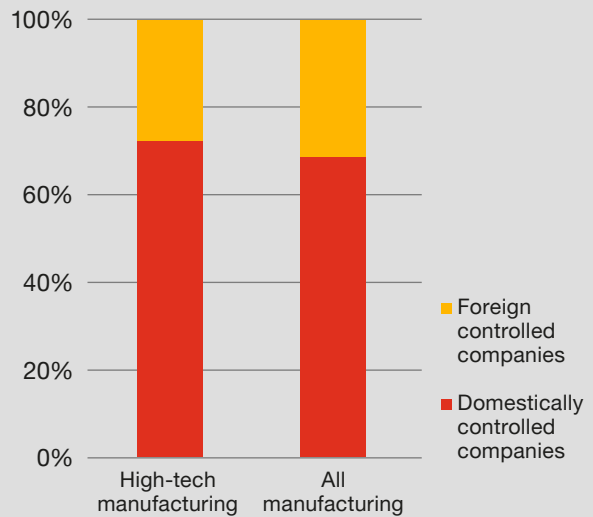
This means that the foreign-owned companies are larger but spend relatively little on overall R&D. This discrepancy could be due to the differences in business models of companies that are foreign or Dutch-owned, or due to structural bottlenecks or a lack of desire for foreign-owned companies to increase their investment in the Netherlands.

**Figure 33** Revenue by ownership structure



Source: CBS, PwC analysis.

**Figure 34** R&D expenditure by ownership structure



Source: CBS, PwC analysis.

### How could the Screening of Investments, Mergers and Acquisitions Act (Vifo Act) impact FDI flows in the high-tech manufacturing industry?

Overall, the Netherlands, due to its political climate, economic development, highly skilled labour force, tax regime and infrastructure, remains an attractive destination for foreign direct investment, as the overall FDI level is still high. There is also high support from the government, for example, through the Netherlands Foreign Investment Agency. However, recently, the Netherlands has been looking more critically at incoming FDI, largely because of rising Chinese investments. On June 1, 2023, the Dutch government adopted the 'Vifo Act', introducing screening for all acquisitions and investments in sectors that are considered vital for national security and public policy.<sup>51</sup> It is likely that a number of companies in the high-tech manufacturing industry might fall under the scope of this regulation. Although we did not find that many companies are owned by countries such as China, as it has already been difficult to attract foreign investors, it is highly likely that it will remain a challenge in light of the recent 'Vifo Act', which applies regardless of an investor's nationality.



# Global value chains and the Dutch high-tech manufacturing industry

## Global value chains bring both economic benefits and vulnerabilities

The Dutch economy is highly integrated into global value chains, being almost twice as dependent on them compared to the EU average. In fact, all high-tech manufacturing industries are heavily dependent on supply chains (both domestic and international). Looking at the foreign trade relationships of the industry, it can be seen that imports and exports account for around 20 to 25% of total Dutch imports or exports, while its GDP share is only 6%.

There is a difference, however, in how the import and export relationships have been shaped. On the import side, all high-tech manufacturing sub-industries (except pharmaceuticals) have a disproportionate import dependency on either one or two of Germany, the US or China. This can be seen as a potential source of vulnerability for the future. On the export side, things seem more certain as the main partners of the industry are mainly other EU member states, such as Germany, France and Belgium. Hence, the industry serves as a channel for buying goods from outside of the EU and selling them to other member states. However, big outliers are the machinery industry, which exports most to Taiwan (the Republic of China), China, Korea and the United States and the other transport equipment industry, which exports mainly to India.

With rising protectionism and geopolitical tensions, all high-tech manufacturing industries must be cautious about their import dependencies and should seek import diversification, while on the export side, the same message especially applies to the machinery industry. In addition, localisation policies in general are inflationary, imply transition costs and have a negative long-run effect on aggregate domestic output. Capturing critical points in the value chains will be essential for competitiveness.

### Points to ponder:

- *How can high-tech manufacturing companies harness the benefits of trade while mitigating their potential vulnerabilities?*
- *Should the government ensure protection for supply chains that are critical for many production and social processes?*

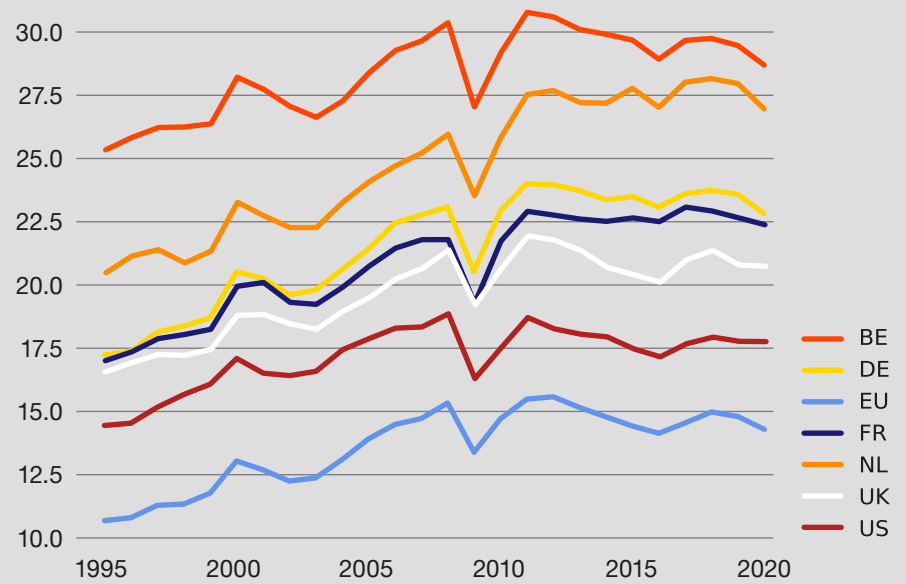




**The Netherlands plays a pivotal role in global value chains**

In 2021, the Netherlands accounted for 3.1% of world exports and 3.2% of global goods imports, while its share of world GDP was only **1%**. This puts the Netherlands as the sixth-largest exporter and eighth-largest importer globally.<sup>52</sup> Furthermore, in 2022, the Netherlands was ranked the 22nd most complex economy.<sup>53</sup> This means that many of its export value chains are difficult to replicate elsewhere. From Figure 35,<sup>54</sup> it can be seen that the Netherlands is the second most integrated country in global value chains among those compared, implying that it buys from and sells to other countries to fulfil its production more than other countries (besides Belgium).

**Figure 35** Average participation in global value chains by country

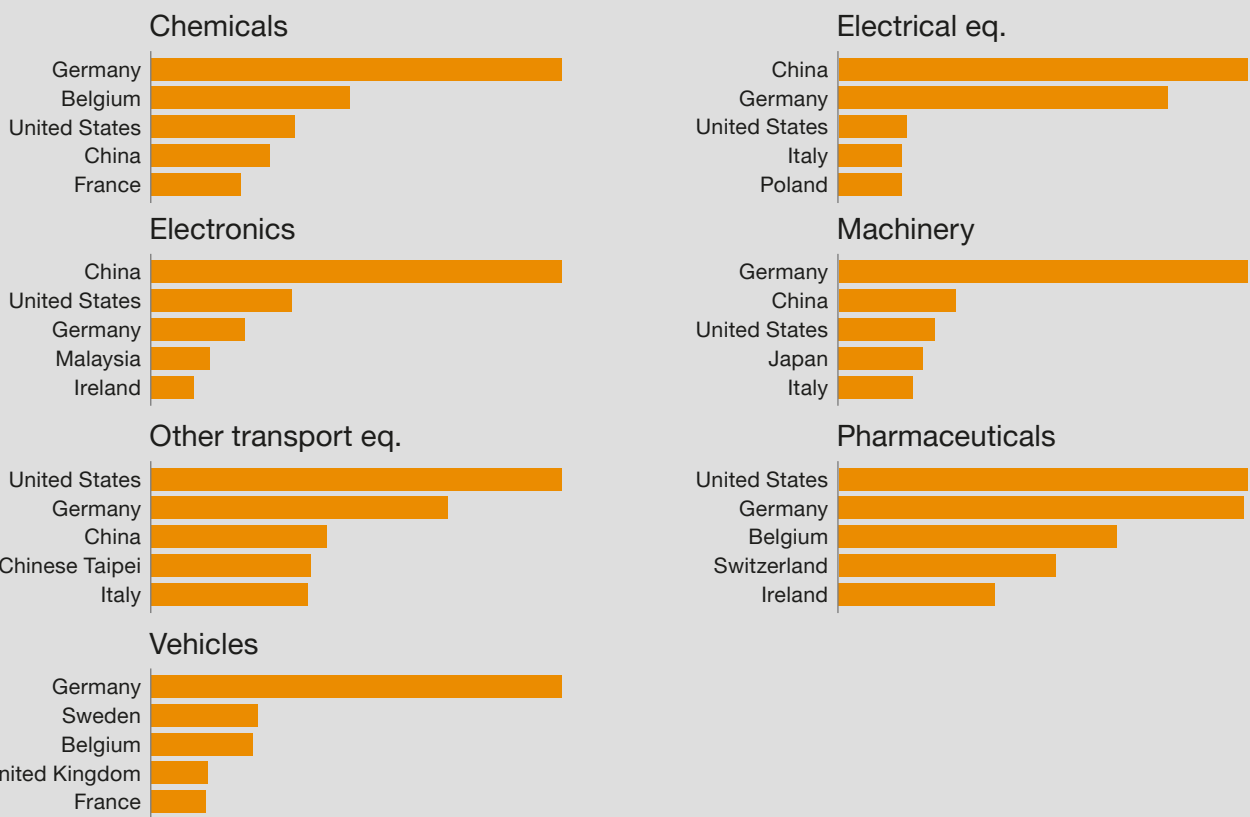


Source: OECD, PwC analysis.

**For its size, the high-tech manufacturing industry is heavily dependent on trade**

In addition, the high-tech manufacturing industry accounts for around 20 to 25% of total Dutch exports and imports, which is up to four times more than its GDP share (6%). However, this import and export share of the Dutch high-tech manufacturing industry is relatively less than for the same industry in all other countries compared.<sup>55</sup> This comes down to the fact that the rest of the Dutch economy is also heavily focused on trade with other countries, unlike the case for bigger economies such as France, Germany and the US. Among the high-tech manufacturing sub-industries, the biggest importers are vehicles (more than 5% of total imports), chemicals (almost 4% of total imports) and electronics (more than 3% of total imports). The biggest exporters are chemicals (more than 7% of total exports), machinery (more than 5% of total exports) and electronics (more than 3% of total exports).<sup>56</sup>

**Figure 36** Top five import partners for Dutch high-tech manufacturing industries



Source: OECD, PwC analysis.

**All high-tech manufacturing sub-industries have a big import reliance on Germany, China or the US**

Among the high-tech manufacturing sub-industries, Germany, China and the United States play a significant role as leading import partners. In addition, industries, especially chemicals, electronics, electrical equipment, vehicles and machinery, are heavily dependent on one or two countries, such as Germany, the US or China, for a large share of their imports (Figure 36). Interestingly, other countries, such as Belgium or other EU member states, are less important, at least in absolute terms, for all high-tech manufacturing sub-industries.



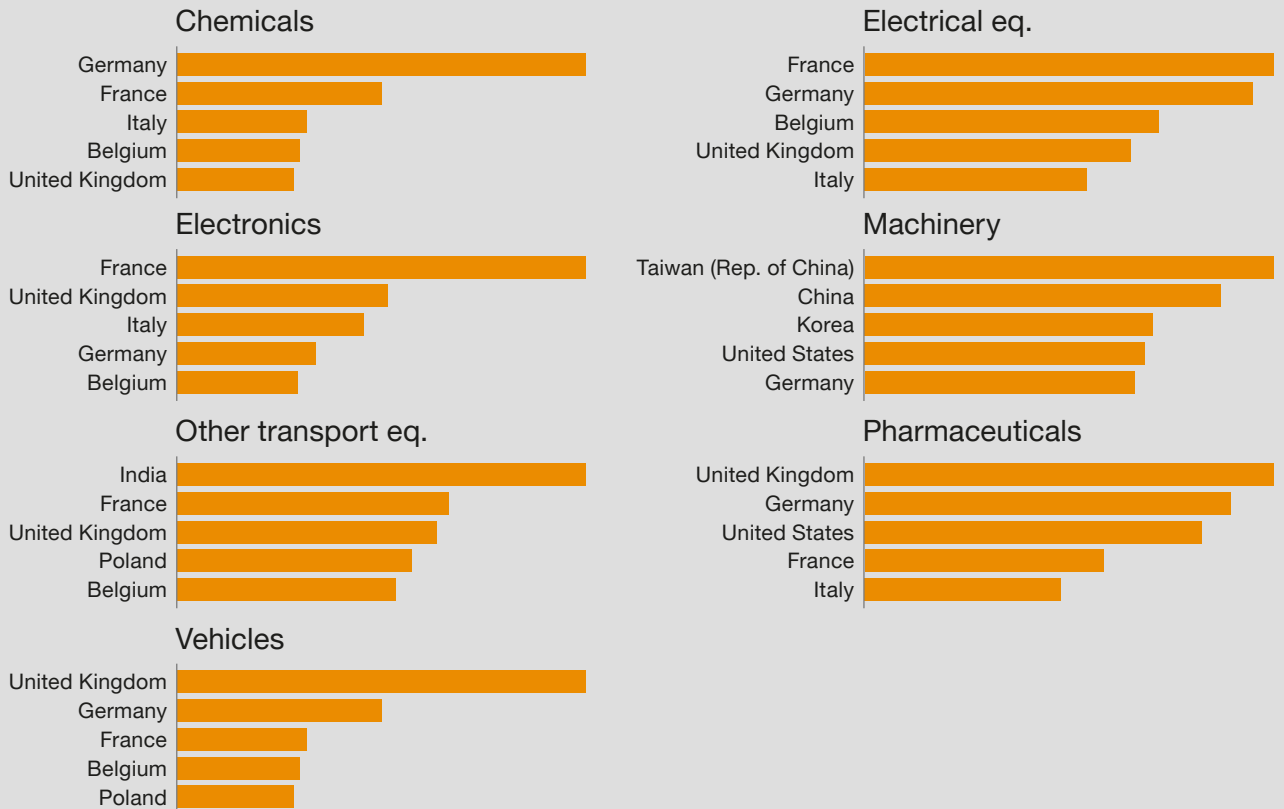
### Critical raw material dependency is a source of potential concern

This is especially true for critical raw materials, such as silicon, rare earth elements, niobium and germanium, that are pivotal in many production processes for high-tech manufacturing goods. The Netherlands indirectly imports almost twice as many critical materials (through other countries as intermediaries) as it does directly.<sup>57</sup> Although the majority of both directly and indirectly imported critical materials have a very low import value, representing less than 1% of the total direct and indirect imports, this does not mean that they are not important. Even materials with small values can cause bottlenecks and dependencies in the import of (processed) products. Germany and China play a crucial role as intermediate links in the Dutch supply chain, especially in indirect imports of critical raw materials.<sup>58</sup>

### Machinery and chemicals are leaders among Dutch industries in revenues from exports

Exports are an important engine for the Dutch economy. Almost 30% of Dutch GDP and employment arise because of earnings from exports of goods and services.<sup>59</sup> The manufacturing sector generates most earnings from exports (€63.2bn, or 25% of the total). Machinery (€11.5bn, or 18.1% of all manufacturing export earnings) and chemicals (€9bn, or 14.2% of all manufacturing export earnings) are leaders within manufacturing and other industries.<sup>60</sup>

**Figure 37** Top five export partners for Dutch high-tech manufacturing industries



Source: OECD, PwC analysis.

### Machinery and other transport equipment might be particularly impacted by protectionism

Most high-tech manufacturing sub-industries also primarily export to other EU member states. However, machinery exports most to Taiwan (Republic of China), China, South Korea and the US and only then to Germany. Other transport equipment's main export partner is India (Figure 37). Hence, the high-tech manufacturing industry does not seem to be heavily exposed to protectionist measures, as its biggest trade partners are within the EU. However, if the international export destinations were to experience more protectionism, that would especially impact the machinery and other transport equipment industries.





### Controlling strategically important global value chain chokepoints is essential to the global competitiveness of the high-tech manufacturing industry and the geopolitical leverage of the Netherlands

As we have seen, although the Netherlands already relies more on trade than other countries with comparable economic development, the high-tech manufacturing industry is even more exposed to foreign trade. On one hand, that is a potential vulnerability, as the industries are sensitive to protectionism and rely on geopolitical and trade stability. Geo-economic fragmentation in the form of increasing restrictions on trade in goods leads to higher import prices, market segmentation and hindered access to technology and knowledge, which especially harms small and open economies like the Netherlands.<sup>61</sup> To some extent, the Netherlands is protected against friction between global trade blocs due to its strong integration into the EU single market. However, localisation policies in general are inflationary, imply transition costs and have a negative long-run effect on aggregate domestic output.<sup>62</sup> This poses challenges to the Netherlands and the high-tech manufacturing industry.

However, as has been the case recently with ASML, if located at critical points of extremely important global value chains, this can also be a source of leverage. The high-tech manufacturing industry is part of a small, open and highly developed Dutch economy, for which it is challenging to compete globally by selling a large volume of goods at lower prices. It can, however, compete by selling the right and best-of-its-kind goods that are vital for many global production processes.<sup>63</sup> Hence, gaining geopolitical leverage and positioning within chokepoints of global value chains are strategies for how the industry can 'punch above its weight'.

### Many high-tech manufacturing companies, such as ASML, are at critical points of the complex global value chains

Modern production relationships are incredibly complex, with many firms in many different industries and countries buying and selling from each other. A good example of that is the semiconductor industry. For example, ASML, which produces extreme ultraviolet lithography machines for semiconductor production, requires around 100,000 parts for its machines.<sup>64</sup> The parts for its machines come from over 5000 different suppliers all over the world, in Europe, the US and Asia.<sup>65, 66</sup> In addition, shipping just one machine requires 40 freight containers, three cargo planes and 20 trucks.<sup>67</sup> Anything that requires a semiconductor (laptops, mobile phones, etc.) is likely to be produced using ASML's machines. Similarly, NXP, a semiconductor producer, is a major player in the global market for chip design and manufacturing, requiring complex production processes to remain competitive.

Therefore, although some high-tech manufacturing firms might not sell a large volume of goods compared to other industries, the products that they sell are pivotal to the production of many other goods globally. Related to this, Dutch companies that provide critical goods, such as ASML, have been recently involved in national security and technological sovereignty debates within the EU, as they are not only important for the Dutch but also the EU and global economies. Managing its economic and security interests, the Dutch government has recently come to a decision to limit the export of the most high-tech semiconductor manufacturing equipment.<sup>68</sup> It is likely that geopolitics will continue playing a role in the future for leading Dutch high-tech manufacturers.



# The economic relationships of the high-tech manufacturing industry

## Domestic production flows and economic relationships

None of the high-tech manufacturing industries have meaningful direct economic relationships with each other: they mostly trade with other industries in the Netherlands or elsewhere. An exception are chemicals and electronics industries that are among the top five most central industries to the Dutch economy. In addition, chemicals is an important buyer for many Dutch industries, while electrical equipment is an important provider of supplies for many industries. Another high-tech manufacturing sub-industry, pharmaceuticals, generates larger-than-its-size employment and income effects in other industries in the Netherlands.

Despite the heavy focus on international trade, the high-tech manufacturing industry still plays a sizable role in the domestic economy. If all of the high-tech manufacturing industries were forced to reduce their production by 10%, it would lead to a GDP loss of 2.8% or €43.5bn, with the indirect effect on the rest of the economy almost twice the direct effect. Similarly, a 10% output reduction in high-tech manufacturing would lead to an employment loss of 1.8%, equivalent to 112,000 jobs, with the indirect effect almost three times as large as the direct effect.

### Points to ponder:

- *Should there be more awareness about the production dependencies among the industries in the Netherlands?*
- *How can the Netherlands better harness the high-tech economic cluster effects on the rest of the economy?*

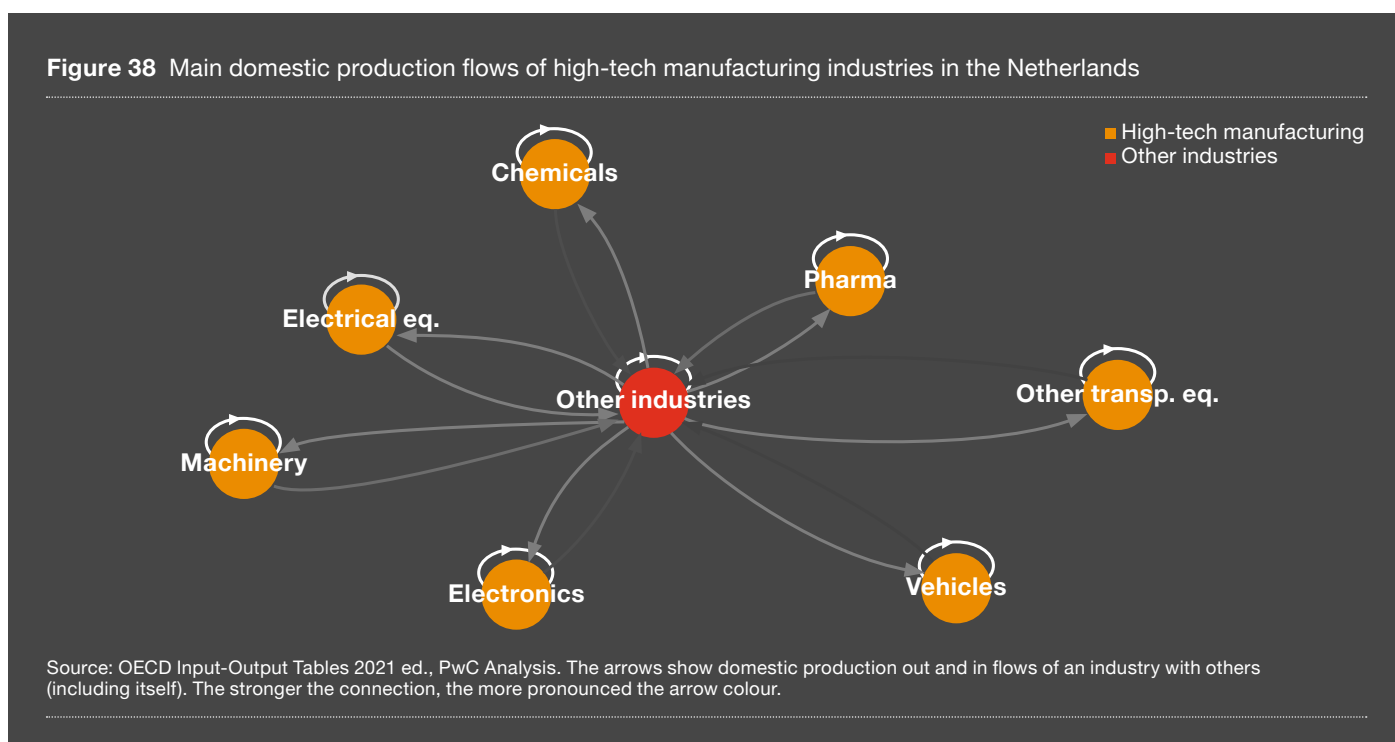
Modern economies can be viewed as complex networks of trade relationships, where companies in each industry trade with each other not only within the economy but also with companies, industries and countries abroad. Due to the highly sophisticated goods it sells and its presence in global markets, the high-tech manufacturing industry is relatively more linked with other economies, industries and companies abroad than the rest of the Netherlands. Nevertheless, the high-tech manufacturing industry has notable economic relationships within the Netherlands as well.

Two things become clear. First, none of the high-tech manufacturing sub-industries have meaningful trade flows with each other, as companies in those industries mostly trade with themselves or companies in other industries. For

example, the electronics industry gets 38% of its intermediate inputs and output from itself, while it sells 40% of its intermediate outputs to other industries. However, from the perspective of other industries, that makes up only 2.7% of all inputs in those industries. This is in contrast with other Dutch industries, which have much stronger production relationships with each other.

**The high-tech manufacturing sub-industries are not directly linked to each other**

Figure 38 illustrates the domestic production flows of the high-tech manufacturing industries.<sup>69, 70</sup> Essentially, these flows capture what share of domestic intermediate inputs and outputs for each high-tech manufacturing sub-industry come from other industries, including the rest of the high-tech



“ Modern economies can be viewed as complex networks of trade relationships, where companies in each industry trade with each other not only within the economy but also with companies, industries and countries abroad.

manufacturing industry. Here we exclude exports, imports and final demand (direct sales to consumers or governments). The more visible the connection between industries, the stronger the economic relationship. The visible connections exceed 10% of trade flows.

### Chemicals and electronics are more central to the Dutch economy than other high-tech manufacturing industries

To assess the centrality of different industries for the Dutch economy, we use a measure based on the production relationships between different industries called ‘eigenvector centrality’.<sup>71</sup> It measures the influence of different nodes in the production network. For example, a higher eigenvector centrality score would mean that an industry is connected to many industries, and its connections themselves are important to the economy. An analogy would be that a movie star who knows other movie stars would score higher than if it knew many extras. We find that chemicals and electronics, according to this measure,<sup>72</sup> are among the top five industries in the Dutch economy, with chemicals having the fourth highest and electronics having the fifth highest measure of centrality to the economic structure.

### Chemicals, electrical equipment and pharmaceuticals stand out for the role they play in the production, employment and wages of other industries

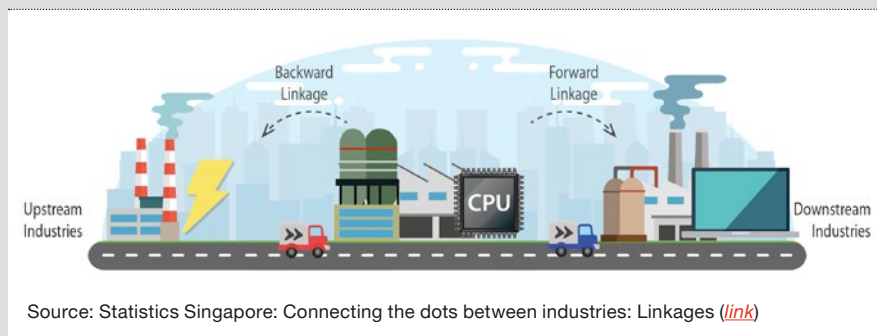
As seen previously, most high-tech manufacturing industries can be considered relatively weakly linked within the Dutch economy as they have stronger ties abroad than domestically. Nevertheless, some of the high-tech manufacturing industries stand out, such as chemicals and electrical equipment, which have important production effects, and pharmaceuticals, which have important employment and income effects on the rest of the economy.

We analysed which high-tech manufacturing sub-industries can be considered key industries. In other words, which high-tech manufacturing sub-industries have strong demand (they buy inputs from or are backward-oriented) or supply (they sell inputs to or are forward-oriented) relationships with the rest of the Dutch economy.<sup>73</sup> In addition, we looked at whether these relationships are concentrated (with a few industries) or broad (with many industries). This allows us to see which industries ‘punch above their weight’ in terms of their importance to the existing domestic economic flows. We performed the key industry analysis looking at three angles: production, employment and income.

### Backward and forward linkages indicate economic interdependence

Industries in the economy can be analysed from their production relationships: who they buy from (backward linkages or the demand side) and who they sell to (forward linkages or the supply side), in order to determine which are more crucial to the economic structure than others.

Figure 39 Example of economic linkages



For example, as shown in Figure 39, an increase in the production of the electronics industry would increase demand for inputs from upstream industries such as energy supply and mining (demand effect). If this effect is strong, the electronics industry would be considered to have meaningful backward linkages. Furthermore, this backward linkage can be concentrated (economic relationships with a few industries) or broad (economic relationships with many industries). Similarly, from the supply side, an increase in the production of the electronics industry would allow the supply of more inputs to downstream industries such as electrical equipment. If this effect is strong, the electronics industry would be considered to have meaningful forward linkages. As with backward linkages, this effect can be concentrated (economic relationships with a few industries) or broad (economic relationships with many industries).



**Chemicals is an important buyer for many Dutch industries, while electrical equipment is an important provider of supplies for many industries**

From the high-tech manufacturing sub-industries, we found that chemicals and electric equipment stand out in terms of their role in domestic production flows. First, chemicals is an industry that, for its size, buys a disproportionately large share of production inputs from many other industries (it is a backward-oriented industry with widely spread effects). Hence, if the chemicals industry were to decrease its production, many industries in the Dutch economy that sell inputs to the chemicals industry would be forced to cut down on a significant portion of their production. This would lead to severe indirect effects, totaling more than might seem from the size of the chemicals industry itself. The same can be said for the electrical equipment industry, although in this case it is

an important supplier of inputs to many other industries in the Dutch economy (it is a forward-oriented industry with widely spread effects).

**Pharmaceuticals creates a disproportionate share of jobs and wages paid elsewhere in the economy**

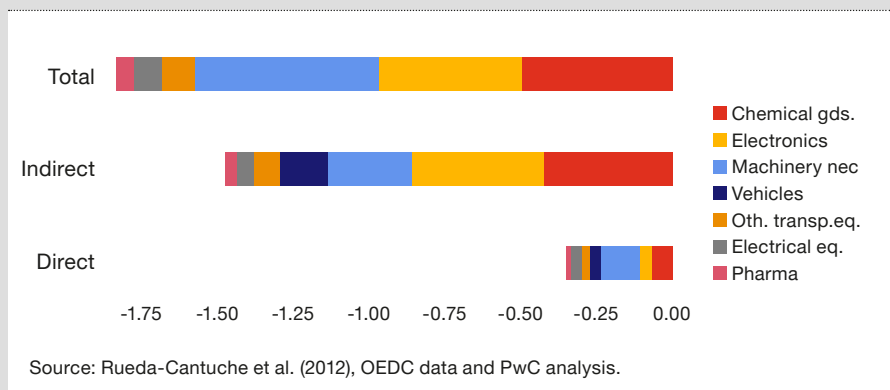
Looking at the employment and income sides, we found that the pharmaceutical industry stands out. It is an important supplier of inputs to many other industries in the Netherlands (it is a forward-oriented industry with widely spread effects). However, in this case, it doesn't induce disproportionate production opportunities in other industries, but it raises the employment and incomes paid to workers in other industries – more than can be seen from the direct contribution of the industry to the economy.

**What would happen if the production of the high-tech manufacturing industry decreased by 10% in five years?**

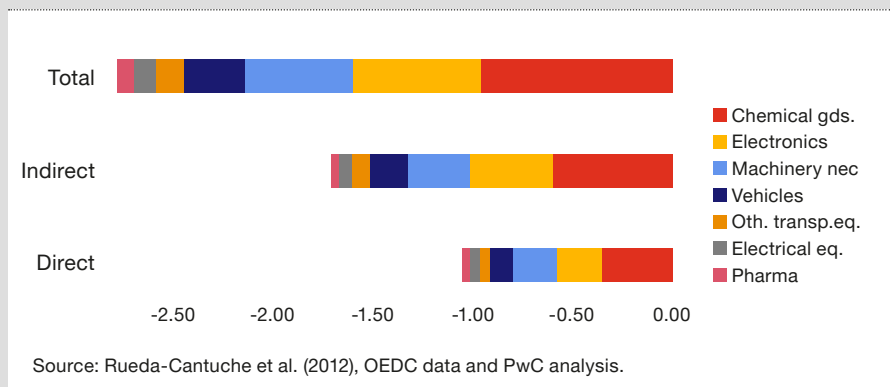
We conducted a scenario analysis, considering a 10% production reduction in all high-tech manufacturing sub-industries. This would be similar to a negative economic shock, for example, a recession, a lack of global demand or severe government regulation.

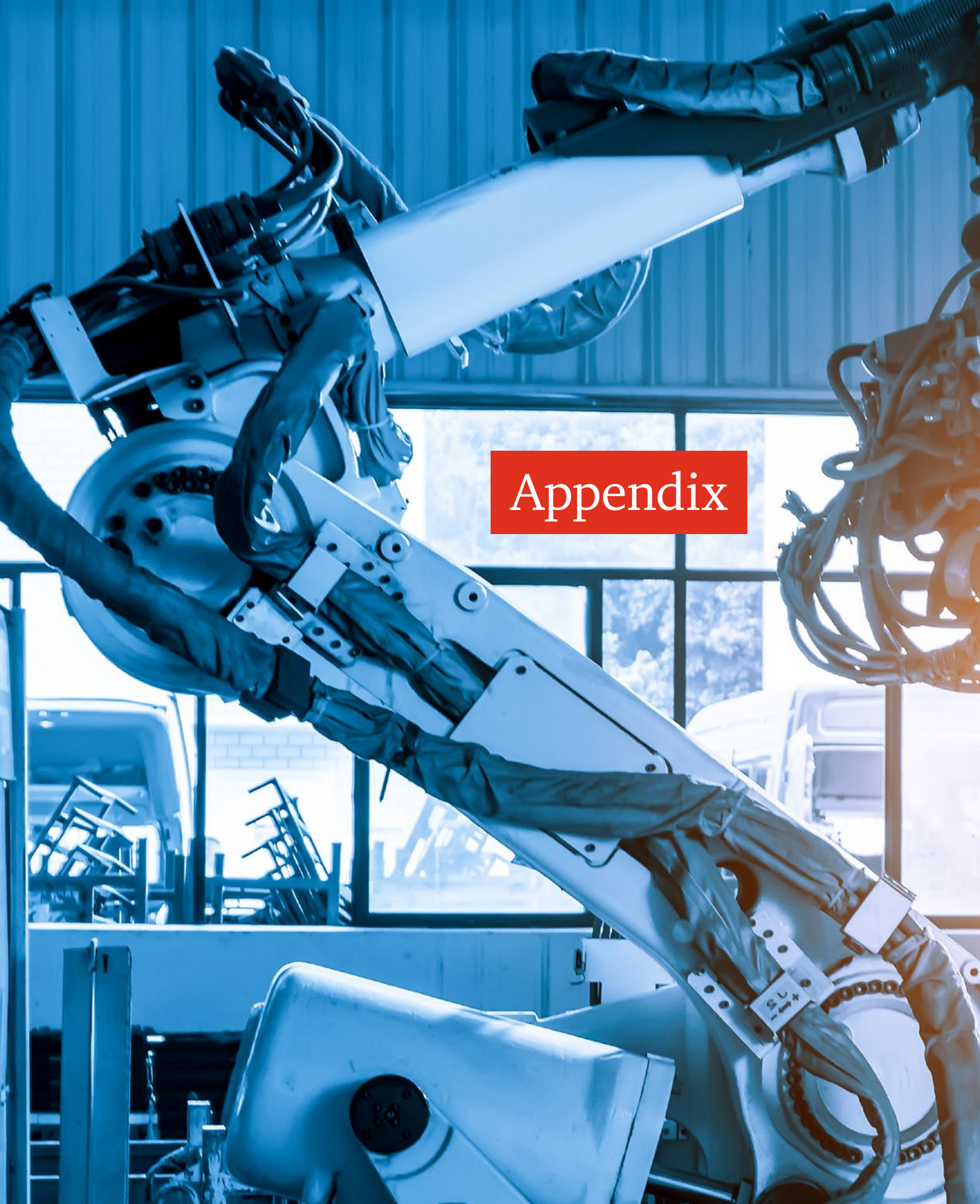
We find that even though most high-tech manufacturing sub-industries are more linked to other industries abroad than the rest of the Dutch economy, a 10% negative shock to the high-tech manufacturing sub-industries would still lead to sizable economic losses (Figure 40). In such a case, 2.8% or €43.5bn of total Dutch GDP would be lost, with the biggest losses coming from the chemicals, machinery and electronics industries. Similarly, on the employment side, 112 000 jobs would be lost (1.8% of the total employment in the Netherlands), again mainly from the role of the three aforementioned industries.

**Figure 40** Output impact of a 10% reduction in the output of all high-tech manufacturing sub-industries



**Figure 41** Employment impact of a 10% reduction in the output of all high-tech manufacturing sub-industries





# Appendix



## Definitions

In this report, we limit ourselves to looking at seven sub-industries that we classify as high-tech manufacturing, based on Eurostat's definition, combining both high-technology and medium-high technology industries.<sup>74</sup> We also use the same industry classification in data from CBS and the OECD. This definition is based on aggregation of manufacturing industries according to their technological intensity (R&D expenditure divided by value added).<sup>7</sup>

It can be noted that other publications on this topic could be using a different definition when referring to high-tech manufacturing. For consistency's sake and to compare with other publications in other EU countries, we chose to use this Eurostat definition, encompassing those seven sub-industries. The full names and codes for the industries are based on the NACE Rev. 2 2-digit level:

- **Chemicals:** manufacture of chemicals and chemical products (20);
- **Electrical equipment:** manufacture of electrical equipment (27);
- **Electronics:** manufacture of computer, electronic and optical products (26);
- **Pharmaceuticals:** manufacture of basic pharmaceutical products and pharmaceutical preparations (21);
- **Machinery:** manufacture of machinery and equipment n.e.c. (28);
- **Other transport equipment:** manufacture of other transport equipment (30);
- **Vehicles:** manufacture of motor vehicles, trailers and semi-trailers (29);

If we use the term 'manufacturing excl. high-tech', we refer to the 10 out of 17 other industries that make up manufacturing, excluding the aforementioned high-tech manufacturing industries.<sup>75</sup>

For referring to 'business services', we include the data for G-N industries based on the OECD industry classification.<sup>76</sup> The data from CBS that refers to business services involving the same industry group includes the H, I, J, K, L, M and N industries.<sup>77</sup>

In addition, to make it easier to pinpoint the main companies that are in each industry, here we have attached a list of the top five largest companies by revenue in each sub-industry that are based in the Netherlands according to Orbis data:

- **Chemicals:** LyondellBasell Industries N.V., Huntsman Holland B.V., Koninklijke DSM N.V., Henkel Global Supply Chain B.V., OCI N.V.

- **Electrical equipment:** Koninklijke Philips N.V., Signify N.V., Alfen N.V., Prodrive Technologies B.V., Royal Smit Transformers B.V.
- **Electronics:** STMicroelectronics N.V., NXP Semiconductors N.V., ASM International N.V., Qiagen N.V., NetApp Holding & Manufacturing B.V.
- **Pharmaceuticals:** Merck Sharp & Dohme International Services B.V., AkzoNobel N.V., Merck Sharp & Dohme B.V., Astellas B.V., AHP Manufacturing B.V.
- **Machinery:** CNH Industrial N.V., ASML Holding N.V., Aalberts N.V., Vanderlande Industries Holding B.V., Canon Production Printing Holding B.V.
- **Other transport equipment:** Airbus SE, Accell Group B.V., Gaiwin B.V., Damen Yachting B.V., Damen Workboats B.V.
- **Vehicles:** Stellantis N.V., IVECO Group N.V., DAF Trucks N.V., Ferrari N.V., Denso Europe B.V.

In Figures 31 and 32, when referring to 'foreign-owned companies', we rely on the CBS definition that 'foreign owned' means that a foreign institution has majority ownership in a Dutch business and is able to determine the general policy of an enterprise.

## Calculation methodology

In this section, we elaborate on the methodology for calculations in several figures.

In Figure 11, we calculate the GDP based on the output approach. (Sub-)industry shares are calculated as gross value added over GDP. We used nominal values because real GDP figures use different basis years depending on the reporting country. Our estimates for all manufacturing industries match those of the World Bank.

In Figure 14, we use the OECD data and look at the total number of employees in each industry.

In Figure 23, 'revenue' is defined as total sales in real terms, while 'profit' is defined as operating gross profit in real terms. We use gross profit as opposed to net profit to account for the fact that depreciation and amortization, both non-cash expenses, are particularly big in manufacturing due to its capital intensity, while they are not as present in the rest of the industries.

In Figure 24, we retrieve the operating margin for ASML, Philips, Shell, and Airbus from Factiva data.

In Figure 25, we use the net operating margin, which is the ratio of net operating surplus (net profits) to total sales (gross output), given on a nominal basis.



In Figure 35, the average participation in GVCs can be measured with the GVC participation index.<sup>78</sup> It provides an estimation of how much an economy is connected to global value chains for its production and foreign trade. The indicator is composed of two components reflecting the upstream and downstream links in international production chains.

We calculate the average participation based on the OECD's Trade in Value Added methodology by taking the average of the foreign value-added content of gross exports (backward participation in GVCs) and the domestic value-added content of foreign gross exports (forward participation in GVCs).<sup>79</sup>

In Figure 38, we use input-output tables 2021 ed. from the OECD and the methodology from Rueda-Cantuche et al. (2012) to calculate the flow index between industries. The flow index is the average of forward and backward linkages that consequently determine how linked to other industries a given industry is in buyer and supplier relationships.

The colour of the arrows indicates the strength of the flow index (the closer the closer to white, the stronger is the flow index). 'Other industries' in the figure encompass all remaining industries out of the 44 present in the input-output tables that are not part of high-tech manufacturing. In addition, in this figure, we do not look at export and import relationships but only consider domestic connections.

To perform the key industry analysis, we follow the methodology in Rueda-Cantuche et al. (2012) and use the normalised backward and forward multipliers and the normalised coefficients of variation. Similarly, to calculate the centrality of industries, we use the flow index as the main variable and perform both eigenvector centrality and betweenness centrality calculations, only reporting the eigenvector centrality.

In Figures 40 and 41, we perform a scenario analysis based on the input output tables and the methodology from the.<sup>80</sup> We use the Leontief inverse as calculated in Rueda-Cantuche et al. (2012) for both the output and employment multipliers.

We consider a scenario in which the output of each high-tech manufacturing industry would decrease by 10% in five years. Then we have a direct effect, which means that the industry itself is shrinking and would impact the Dutch economy in terms of output and employment. In addition, there is the indirect effect, which based on the strength of the Leontief multiplier, determines the impact on other industries in the economy. Hence, the total effect is the direct and indirect effect combined.



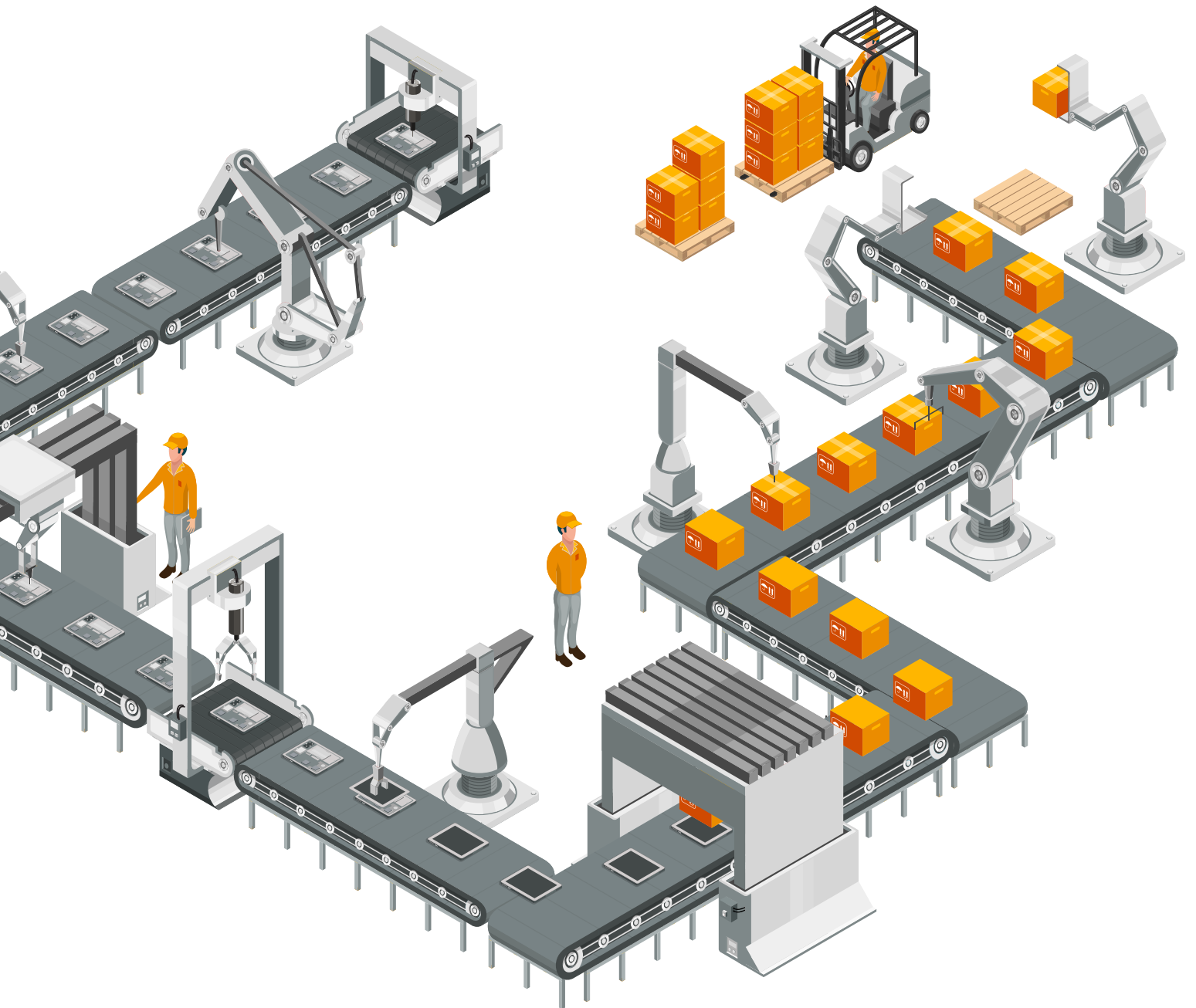
# Acknowledgments (alphabetically)

## Authors:

Astrid van der Werf  
Guntars Upis  
Iris Oehlmann  
Jan Willem Velthuisen  
Jose Castillo  
Ricardo Ribas Santolim

Chief Economist Office  
Chief Economist Office  
Clients & Markets  
Chief Economist  
Chief Economist Office  
Chief Economist Office

PwC Netherlands  
PwC Netherlands  
PwC Netherlands  
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# Endnotes

- 1 Eurostat: Glossary: High-tech classification of manufacturing industries. We include both high and medium-high technology industries. Industry names in the text are abbreviated.
- 2 CBS and Companyinfo.nl
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- 50 For explanation and definition used, see Appendix on page 43.
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# Contacts



**Jan Willem Velthuisen**  
*Chief Economist*  
PwC Netherlands  
E: [jan.willem.velthuisen@pwc.com](mailto:jan.willem.velthuisen@pwc.com)



**Jeroen van Kessel**  
*Assurance Partner,  
Member of the Assurance Board*  
PwC Netherlands  
E: [jeroen.van.kessel@pwc.com](mailto:jeroen.van.kessel@pwc.com)



**Mathieu Rosier**  
*Advisory Partner, Industrial Manufacturing &  
Automotive Industry Leader*  
PwC Netherlands  
E: [mathieu.rosier@pwc.com](mailto:mathieu.rosier@pwc.com)



**Robert du Burck**  
*Deals Partner,  
Markets Leader Region South*  
PwC Netherlands  
E: [robert.du.burck@pwc.com](mailto:robert.du.burck@pwc.com)

