

# Looking under the hood: Examining the technology position of the Netherlands

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## Summary

While Europe as a whole faces major challenges with regard to its competitiveness, the Netherlands also has its own specific bottlenecks. The structural shortage of technical talent, lagging and increasingly concentrated corporate R&D investment, and the limited value generated in knowledge intensive sectors are placing growing pressure on the country's innovation capacity. The Dutch technology position is on a downward trajectory, as evidenced, among other things, by the declining share of patents across all ten key technologies identified in the National Technology Strategy. It is precisely these technologies—linked to critical domains such as security, climate and energy, health and biotech, and digital technologies—that should form the areas in which the Netherlands excels internationally.

Although the Netherlands has a strong startup ecosystem and even hosts a relatively large number of young companies in fields such as AI and quantum technology, growth into scale ups is stalling. A lack of large financing rounds and shortages of technically skilled personnel are hampering the scaling up of radical innovation and new technology driven business activity. These constraining factors contribute to the so called innovation paradox: the Netherlands excels in fundamental and applied research, yet struggles to translate knowledge into innovations, new sustainable economic activity, and economic growth. The successive stages of the innovation chain—from scientific publications to patents and subsequently to entrepreneurship—show a clearly declining Dutch share.

Sectoral structure also plays an important role. Low technology products and sectors with relatively low growth in value added are overrepresented in the Netherlands, while only a limited number of high tech sectors perform strongly. Moreover, Dutch companies structurally invest less in R&D than their international competitors within the same sectors, further eroding the country's technological edge. At the same time, there are clear opportunities to substantially scale up the production and export of high value technology products, ranging from medical imaging equipment and vaccines to photonic chips.

Strengthening the Netherlands' competitive position in a sustainable way therefore requires more than simply repairing a faltering innovation engine. Innovation capacity itself must be scaled up through targeted intensification in key technologies, increasing R&D intensity in promising sectors, and creating conditions that allow radical innovations and new business activity to grow and scale. This calls for a stronger entrepreneurship infrastructure and culture, more experimental development, improved financing options for technological scale ups, and closing the shortage of technical talent.

Only when all these components of the innovation chain function effectively and are well aligned can the Dutch innovation engine become a successful driver of prosperity.

# 1 Introduction

Just over a year ago, Mario Draghi published his report, a comprehensive analysis of Europe's economic position in a world increasingly dominated by the United States and China—particularly with regard to critical technologies. The report paints an urgent picture: Europe risks falling behind and must make fundamental choices to strengthen its competitiveness. Innovation plays a key role in this regard, serving as a crucial engine for productivity growth and prosperity (Draghi, 2024).

While this analysis provides valuable strategic direction at the European level, the Dutch context requires a more specific and sharper lens to properly account for differences in scale, economic structure, and the innovation system (TNO Vector, 2025a). In other words, it calls for a closer look “under the hood.”

At the request of the Ministry of Economic Affairs (EZ), and partly as input for the advisory report *The roadmap to future prosperity* by Wennink (2025), this study therefore focuses on the central question: how can the Netherlands strengthen its competitive position? In this report, we examine the Netherlands' competitiveness and assess the extent to which targeted investments in Research, Development & Innovation (RD&I) are required. In our analysis under the hood, we investigate three pillars of Dutch competitiveness:

- the knowledge position,
- the technology position, and
- the entrepreneurship position.

Based on this analysis, we formulate recommendations to strengthen the Netherlands' competitive position in a sustainable manner. The conclusion is clear: the Netherlands cannot afford to rest on its laurels. A clear break with current trends is needed to remain competitive in a rapidly changing world.

## Reading guide

This report is structured into five chapters, which together provide insight into the competitive and technological position of the Netherlands. Chapter 2 outlines the broader European context by summarising the key findings of the Draghi report. Chapter 3 then focuses specifically on the Netherlands and analyses the state of national competitiveness, paying particular attention to bottlenecks such as lagging R&D expenditure, shortages of technical talent, sectoral structure, and productivity development. Chapter 4 deepens this analysis by examining the Dutch technology position along the key stages of the innovation chain: knowledge (scientific publications), technology (patents), and entrepreneurship (startups, scale ups, and investments). This chapter also zooms in on the ten key technologies identified in the National Technology Strategy. Finally, Chapter 5 concludes the report with a synthesis of the findings and emphasises the urgency of accelerating the Dutch innovation engine.

## 2 European competitiveness

Europe’s competitiveness is under pressure, and innovation is both the cause of this challenge and its solution. Productivity in EU Member States has lagged behind that of other major economies for many years. According to Draghi (2024), this gap is increasingly driven by the extent to which the European Union falls short in technology development and innovation. While the United States derives much of its productivity growth from the tech sector, Europe’s tech sector lags behind, and with it Europe’s overall productivity growth (Draghi, 2024; McKinsey & Company, 2025).

This technological gap translates into growing dependencies, posing risks to economic resilience and strategic autonomy. For essential technologies and infrastructure, the EU is heavily dependent on a small number of non-European players, including in semiconductor manufacturing, AI models, quantum computing, cloud services, and critical raw materials. Given that opportunities also exist, strengthening Europe’s technological position is not only an economic challenge but also a geopolitical necessity.

Draghi (2024) illustrates the lagging performance of Europe’s tech sector, among other things, by pointing to the limited number of technology companies that Europe is able to create and retain. Of the world’s 50 largest technology companies, only a handful are European. Moreover, over the past 50 years, not a single EU based company has been founded that now has a market capitalisation exceeding €100 billion, compared with six US companies valued at at least €1 trillion. In addition, nearly 30% of unicorns founded in Europe relocated their headquarters abroad between 2008 and 2021, predominantly to the United States.

Draghi (2024) also notes that R&D investment by European companies lags behind that of their US counterparts. In 2021, European firms spent approximately €270 billion less on R&D than US companies. Furthermore, total investment by large European companies in 2022 was around €700 billion lower than that of US corporates, with the largest gap occurring in the tech sector, amounting to €450 billion. This gap has continued to widen in recent years (McKinsey & Company, 2025; see also Figure 1).

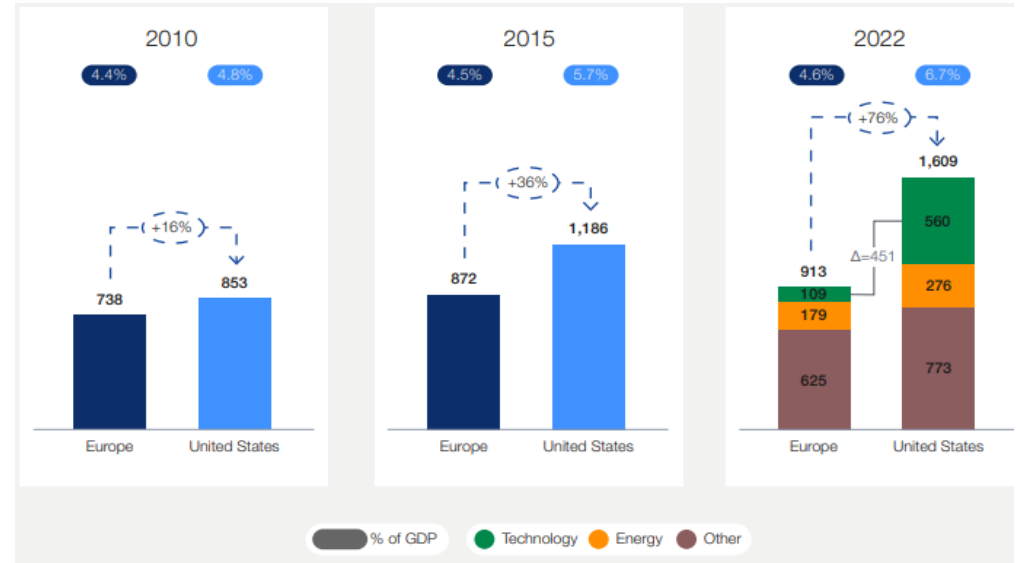


Figure 1: CAPEX- and R&D-expenditure of European and American companies with > \$1 billion revenue, for the period 2010-2022 (Source: McKinsey & Company, 2025).

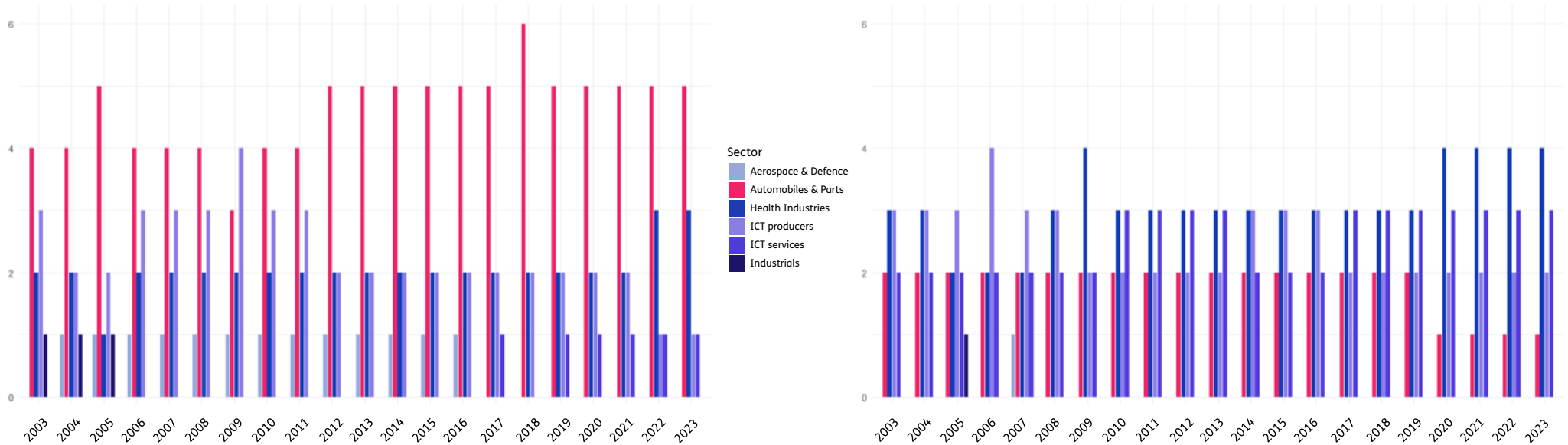


Figure 2: Sector composition of the top 10 most R&D-investing companies from the EU27 (left) and the US (right), within the Industrial R&D Scoreboards 2003–2023 (Source: JRC, 2003–2023, adapted by TNO Vector).

Draghi (2024) also characterises Europe’s sectoral structure as static. Whereas Europe predominantly focuses its innovation efforts on mature technologies and established markets, the United States places greater emphasis on radical innovation and growth markets. As a result, the top R&D investors in Europe have for the past two decades been dominated by the automotive industry, while the leading R&D investors in the United States are primarily concentrated in ICT and biotechnology (JRC, 2024; see also Figure 2).

Draghi (2024) identifies several underlying causes that contribute to Europe’s lagging innovation capacity, including:

- **Stagnating technology transfer:** At European knowledge institutions, the emphasis remains strongly on research and education, while incentives to commercially exploit knowledge are limited. As a result, only around one third of patents originating from European universities are commercially utilised.

- **Fragmented capital markets:** The lack of an integrated capital market hampers the financing of scale ups. Only 5% of global venture capital (VC) funds are raised in the EU, compared with 52% in the United States and 40% in China.
- **Fragmented and stringent regulation:** European regulation entails high administrative burdens and acts as a brake on investment and scaling.
- **Insufficient demand:** Not only does technology development lag behind, but the adoption of new technologies is also slower. European companies invest less in technology than their US counterparts (McKinsey & Company, 2025).
- **Inadequate European infrastructure:** It is estimated that capital investments of €13–16 billion will be required by 2030 to build and modernise technological infrastructures across the European Union—an increase of 200% (EIB, 2025). This would enable operators—primarily research and technology organisations—to keep pace with critical and emerging technologies and remain globally competitive (TNO Vector, 2024a). The largest investment needs are in microelectronics and clean energy, followed by rapidly evolving sectors such as quantum technology, artificial intelligence (AI) and data, and aerospace (EIB, 2025).

### 3 Dutch competitiveness

Although the Netherlands still belongs to the group of European innovation frontrunners, its competitiveness is deteriorating, and Dutch companies are finding it increasingly difficult to innovate and compete. Figure 3 shows that the Netherlands fell in the Global Innovation Index from 2nd place in 2018 to 8th place in 2025 (WIPO, 2018–2025). Over the same period, the Netherlands also dropped from 4th to 10th place in the World Competitiveness Ranking (IMD, 2018–2025).

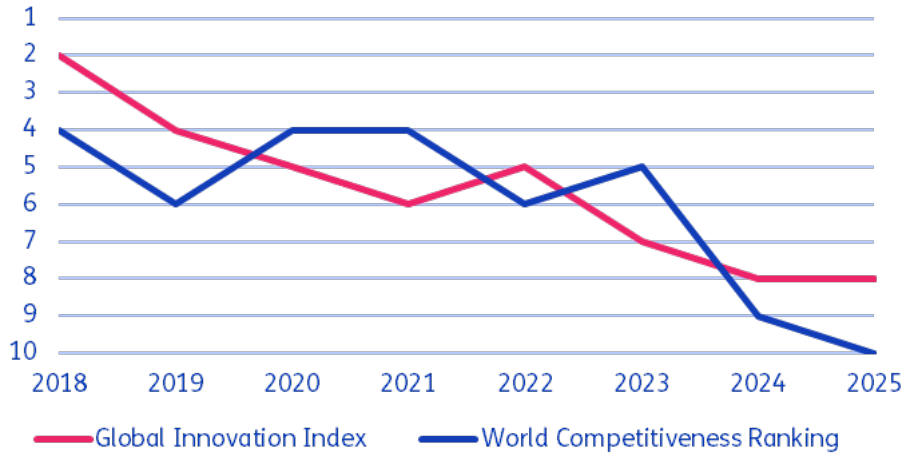


Figure 3: Development of the Dutch position within the Global Innovation Index (WIPO) and the World Competitiveness Ranking (IMD), in the period 2018-2023 (Source: WIPO & IMD, adapted by TNO Vector).

The Netherlands therefore not only faces the broader European challenges outlined in the previous chapter, but also confronts a number of country specific bottlenecks that further put pressure on its competitiveness. These bottlenecks are discussed in this chapter.

#### 3.1 Dutch R&D expenditure lags behind

Investment in R&D forms the foundation for new knowledge and innovation. However, the Netherlands does not meet the European R&D target of 3% of GDP. Dutch R&D intensity has remained below the OECD average of 2.70% since 2017 (TNO Vector, 2025a; see Figure 4). Recent analysis further indicates that, under the current policy, R&D intensity is at risk of

declining even further, to approximately 2% of GDP by 2030 (TNO, 2025a; see Figure 5).

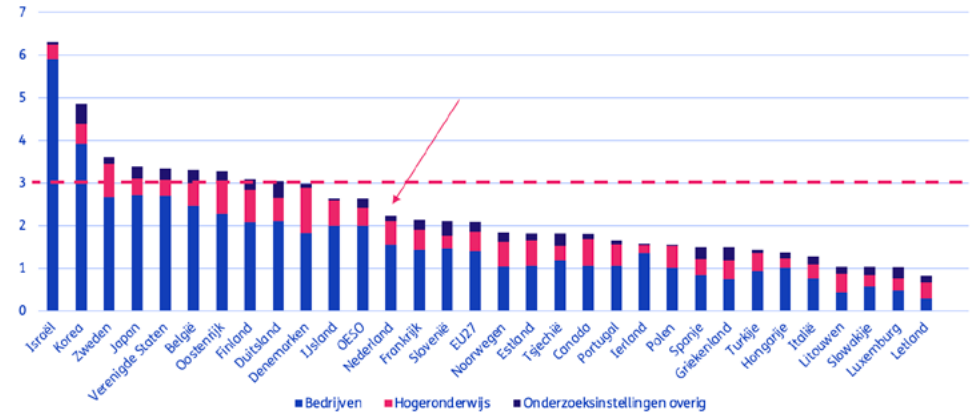


Figure 4: R&D expenditure of OECD countries as a percentage of GDP in 2023, by performing sector (Source: OECD MSTI database, 2025; adapted by TNO Vector).

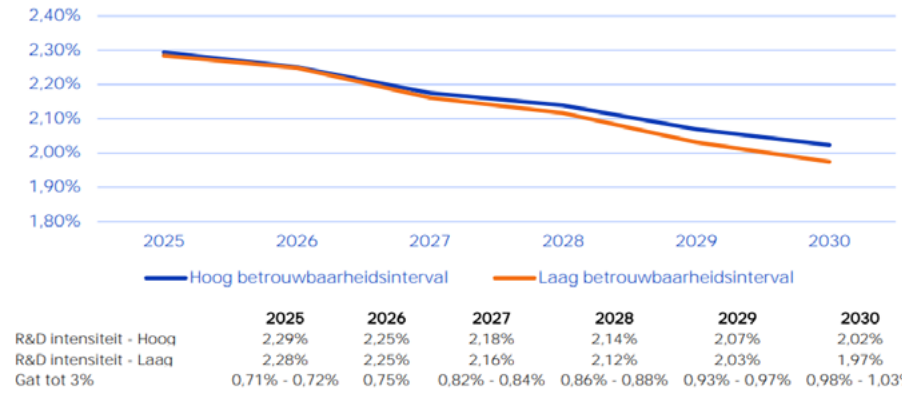


Figure 5: Development of Dutch R&D intensity 2025-2030 (Source: TNO, 2025a).

Recent research by TNO further shows that private R&D expenditure in the Netherlands has become increasingly concentrated in a small number of companies and sectors. That is, the top three to five companies with the highest R&D spending account for a growing share of total private R&D expenditure in the Netherlands (Kempen et al., 2025). Figure 6 shows that ASML has for many years been the largest R&D investor in the Netherlands (TNO, 2024). This concentration makes the knowledge economy vulnerable, as a substantial share of total R&D expenditure is carried out by a single company (Geurts, 2024).

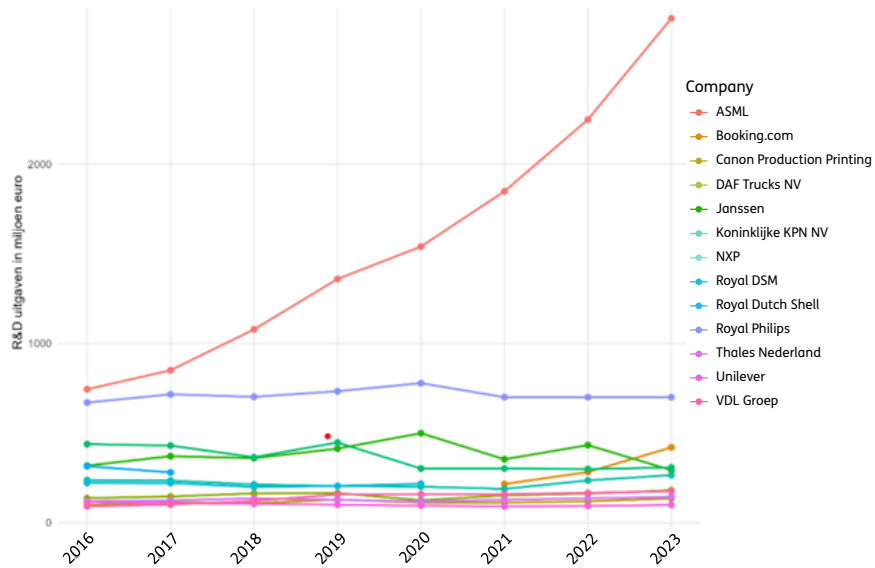


Figure 6: R&D expenditure over time for a selection of companies from the Dutch R&D Top 30 (Source: TNO, 2024).

Compared with other knowledge intensive economies, the Netherlands places relatively strong emphasis on fundamental and applied research. The most market oriented phase of R&D—experimental development, in which knowledge is translated into concrete, applicable technologies, products, and processes—lags behind (OECD, 2025; TNO, 2025b; see Figure 7). This is an area where both applied research organisations, such as TNO, and companies have an important role to play in jointly bridging this gap and accelerating the translation of knowledge to the market.

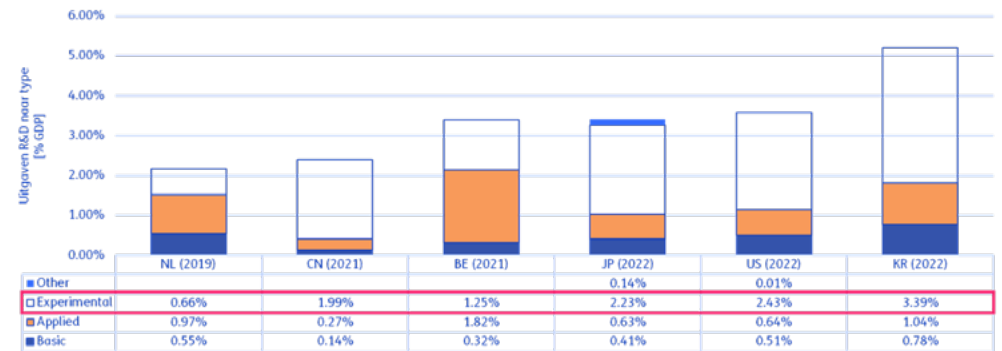


Figure 7: Share of R&D expenditure in OECD countries by type of R&D (2021) (Source: OECD, 2025; adapted by TNO).

### 3.2 Further concentration of the sectoral structure

The Dutch sectoral structure is less static than the European one, but it does show signs of becoming increasingly narrow. Based on the Dutch Top 30 R&D (TW, VNO NCW & TNO, 2024), it is clear that the Dutch sectoral structure has changed over the past 20 years (see Figure 8). Whereas industry, ICT, chemicals and energy initially played a larger role, their relative importance has declined in recent years. This suggests an increasing concentration of investments within the Dutch innovation ecosystem. At present, the Netherlands primarily focuses on innovation in technologies and markets in ICT, industry and others.

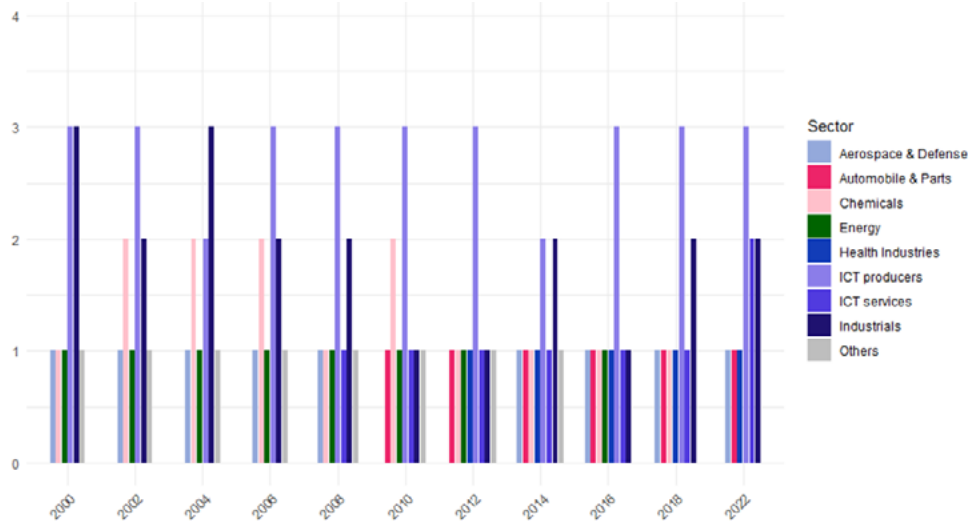


Figure 8: Sectoral breakdown of the top 10 companies investing most in R&D in the Netherlands, 2003–2023 (Source: Top 30 R&D (TW, VNO-NCW & TNO, 2024), adapted by TNO Vector).<sup>1</sup>

Table 1 presents the top three R&D investors and their associated sectors for the United States, the European Union, and the Netherlands. The table confirms that the EU indeed has a static sectoral structure, dominated by high levels of R&D investment in the automotive industry. The sectoral structure of the United States, by contrast, shows greater dynamism, with the focus shifting towards ICT in recent years. The sectoral structure of the Netherlands displays more diversity; however, the Dutch R&D landscape has been dominated over the past 20 years by Philips, ASML, and NXP.

	2002	2011	2021
US	Microsoft (ICT services) Ford (auto) Pfizer (health)	Microsoft (ICT services) Intel (ICT producers) Merck (health)	Alphabet (ICT services) Meta (ICT services) Microsoft (ICT services)
EU	Mercedes-Benz (auto) Siemens (ICT producers) Volkswagen (auto)	Volkswagen (auto) Mercedes-Benz (auto) Bosch (auto)	Volkswagen (auto) Mercedes-Benz (auto) Bosch (auto)
NL	Philips (industrials) Akzo Nobel (chemicals) ASML (ICT producers)	Philips (industrials) ASML (ICT producers) NXP (ICT producers)	ASML (ICT producers) NXP (ICT producers) Philips (industrials)

Table 1: Top 3 R&D investors and associated sectors in the US, the EU and the Netherlands (Source: JRC (2003–2023), adapted by TNO Vector).<sup>2</sup>

<sup>1</sup> For the companies in the Dutch Top 30 R&D, the same sector classification has been used as in the JRC Industrial R&D Investment Scoreboard (2003–2022). Only for VDL has a different sector classification been chosen, namely 'Industrials' (instead of 'Automobile & Parts').

<sup>2</sup> The table has been compiled using the JRC Industrial R&D Investment Scoreboard (2003–2023) and has been adjusted to exclude R&D investors that have their headquarters in the Netherlands but do not carry out R&D here (such as Airbus, Stellantis, STMicroelectronics and CNH). The years in the JRC rankings are one year behind: for example, R&D expenditure for 2002 appears in the 2003 ranking.

### 3.3 Shortage of technical talent

The number of technical graduates in the Netherlands remains insufficient, and vacancies in the technology sector continue to be difficult to fill. In particular, the Netherlands lags behind in the number of graduates in science, technology, engineering and mathematics (STEM). The Netherlands has 15.4 STEM graduates per 1,000 young adults, compared with an EU average of 23 (TNO Vector, 2025a; see Figure 9).

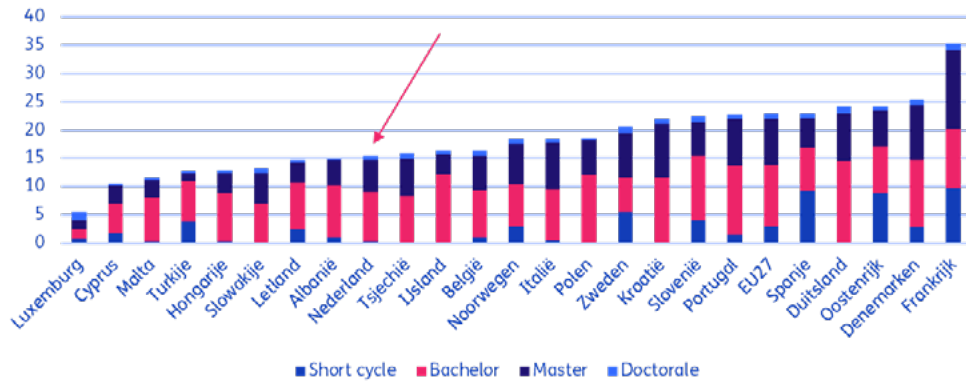


Figure 9: STEM graduates from EU Member States in 2022, by level of education and per 1,000 inhabitants aged 20–29 (Source: Eurostat, 2025; adapted by TNO Vector).

The labour market for ICT and technical professions in the Netherlands is also extremely tight. There is a high level of labour market tension, as demand for technical occupations structurally exceeds labour supply, reflected in a large number of vacancies that remain unfilled (UWV, 2025; PTvT, 2025). The vacancy rate—the number of vacancies per 1,000 jobs—for technical occupations more than doubled over the period 2011–2021, increasing from 20 to 50 (ROA & SEO, 2022). More than half of all open vacancies in the Dutch technology sector (56%) are difficult to fill (McKinsey & Company, 2023).

At the same time, Figure 10 shows that the Netherlands’ ability to attract, develop and deploy talent has increased cautiously over the past few years. However, this trend should be interpreted with care, as it remains sensitive to economic conditions and does not take recent policy measures into account.

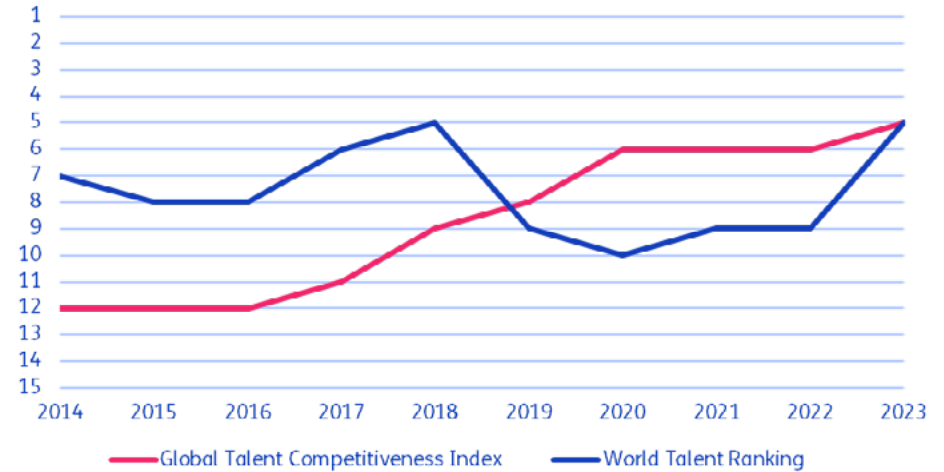


Figure 10: Development of the Netherlands’ position in the Global Talent Competitiveness Index (INSEAD) and the World Talent Ranking (IMD) between 2014 and 2023 (Source: INSEAD & IMD, adapted by TNO Vector).

### 3.4 Slowing labour productivity growth

In addition, growth in labour productivity has been slowing down, leaving the Netherlands in a weaker position than comparable European countries in this respect (TNO Vector, 2025a). Figure 11 shows that overall labour productivity growth in the Netherlands lags behind that of peer countries. This is due to a combination of declining activity in extractive industries and weaker performance in growth sectors such as information and communication and manufacturing (TNO Vector, 2025b).

Figure 11 also shows that the Netherlands lags behind other highly productive countries in the creation of high productivity jobs, particularly in the tech sector (TNO Vector, 2025b). This contrasts with European benchmark countries. An in depth study by TNO Vector shows that countries such as Sweden and Germany compensate for the shift towards low productivity services through strong job growth in high productivity sectors such as ICT services, machinery, and electrical engineering (TNO Vector, 2024a).

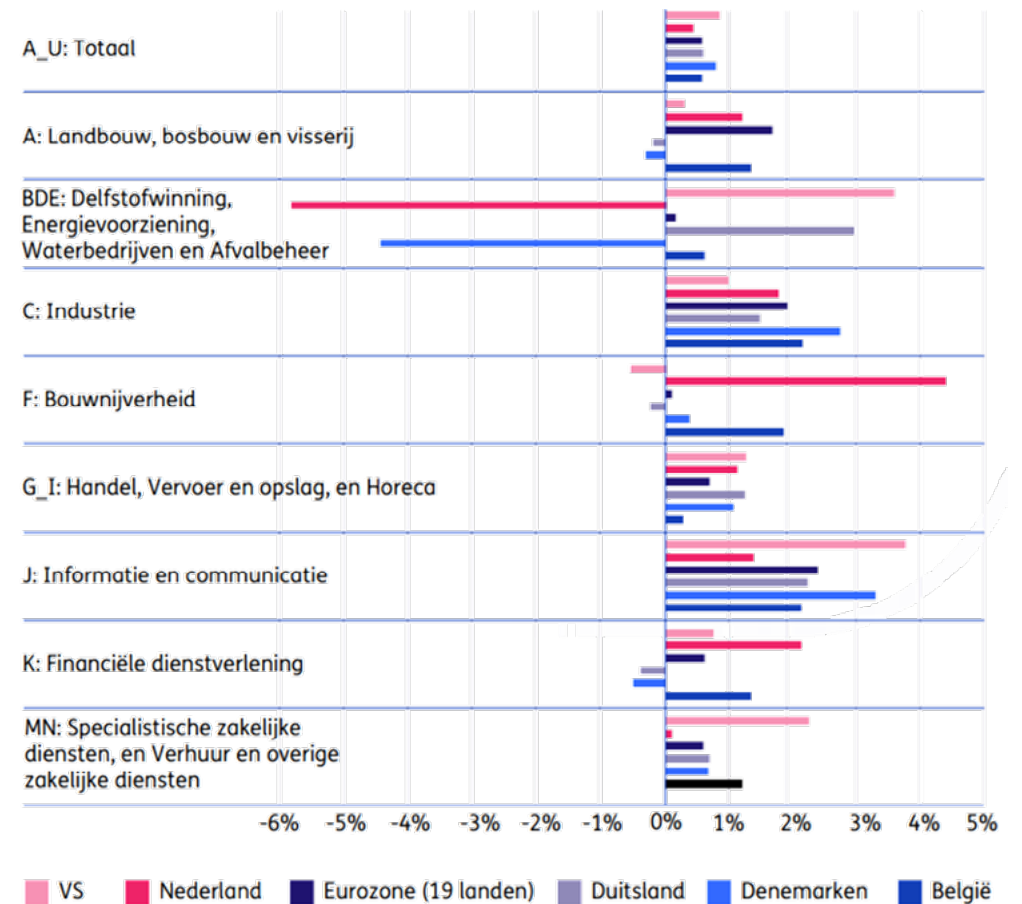


Figure 11: Average annual productivity growth by sector (in %): value added per employee, 2014–2019 (Source: OECD, adapted by TNO Vector, 2025b).

In the Netherlands, employment is shifting from high productivity to low productivity sectors. Figure 12 shows that sectors such as IT, telecommunications, travel agencies, and wholesale trade have experienced the strongest growth in the Netherlands since 1996. Most of these sectors are relatively small in the Dutch economy.

Figure 12 also shows that growth in large sectors such as real estate, manufacturing, health and social care, and legal, accounting and consultancy services has lagged behind. This indicates strong job growth in sectors with low productivity, while the share of employment in productive sectors such as financial services, manufacturing and telecommunications is declining (TNO Vector, 2025b).

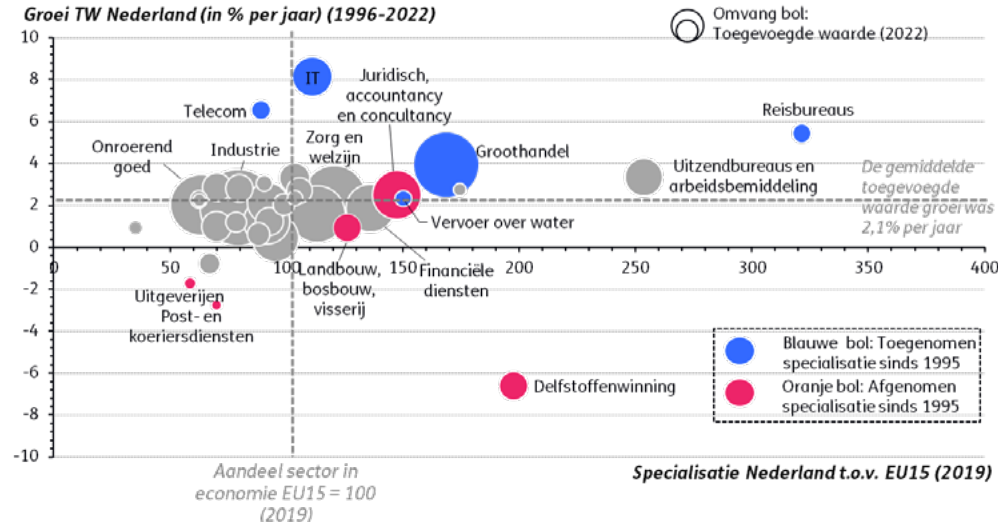


Figure 12: Growth in value added in the Netherlands (% , 1996–2022) compared with the Netherlands' specialisation (2019) (Source: TNO Vector).

Figure 13 provides a more detailed analysis of Figure 12. It shows that within the manufacturing sector, growth in value added is primarily driven by machinery manufacturing, in line with earlier findings. The Netherlands has also become more specialised in this area compared with other countries (TNO Vector, 2025b).

Figure 13 further shows that in other growth sectors, such as the electrical engineering industry, the Netherlands has become less specialised relative to other European countries since 1996 (TNO Vector, 2025b). This indicates potential for further growth. Finally, Figure 16 shows that large industrial sectors in which the Netherlands is relatively specialised, such as chemicals and food and beverages, exhibit only limited growth (TNO Vector, 2025b).

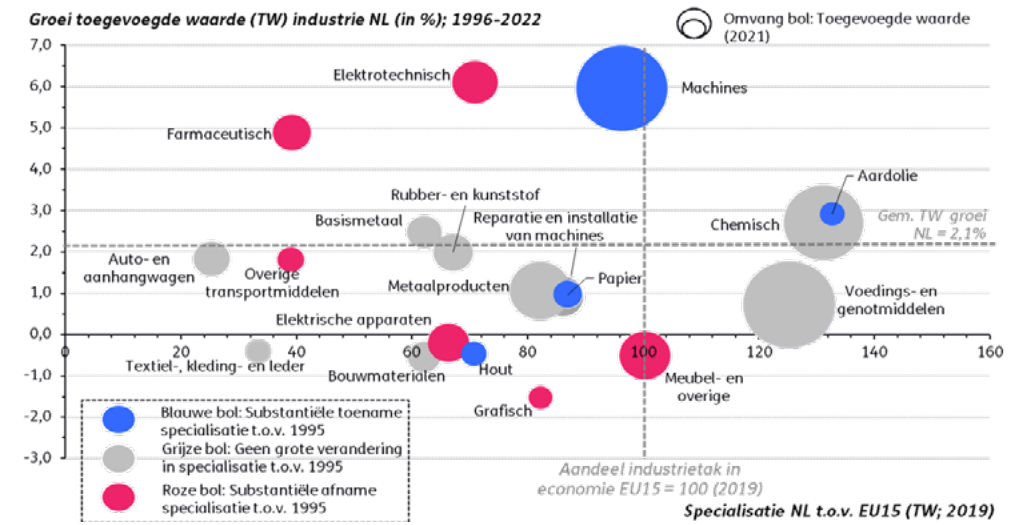


Figure 13: Growth in value added in Dutch industry (% , 1996–2022) compared with the Netherlands' specialisation (2019) (Source: TNO Vector).

### 3.5 Increasing investment needs

The Dutch sectoral structure is often cited as an explanation for the Netherlands' current competitive position. Dutch competitiveness is indeed partly shaped by sectoral structure, as the Dutch economy relies heavily on services such as trade, transport and business services—sectors that by nature invest less in R&D than, for example, high tech industries. As a result of this sectoral structure, the Netherlands scores lower on R&D intensity than benchmark countries (TNO, 2025a; 2025b; see Figure 14, where the sectoral structure effect is shown in orange).

However, recent research by TNO shows that, even after correcting for sectoral structure, Dutch companies have been investing less and less in R&D. Across almost all sectors, Dutch firms systematically invest less in R&D than their international competitors (the intrinsic effect; shown in blue in Figure 14). Notably, the Netherlands' overall R&D gap (represented by the dotted line in Figure 14) widened over the period 2013–2022 from approximately –0.6% to nearly –1.0% of GDP. This increase is almost entirely attributable to the growing intrinsic effect (TNO, 2025a; 2025b).

The Netherlands' R&D shortfall therefore cannot primarily be explained by the structure of the Dutch economy, but rather by a generally lower willingness among Dutch companies to invest in innovation (TNO, 2025b).

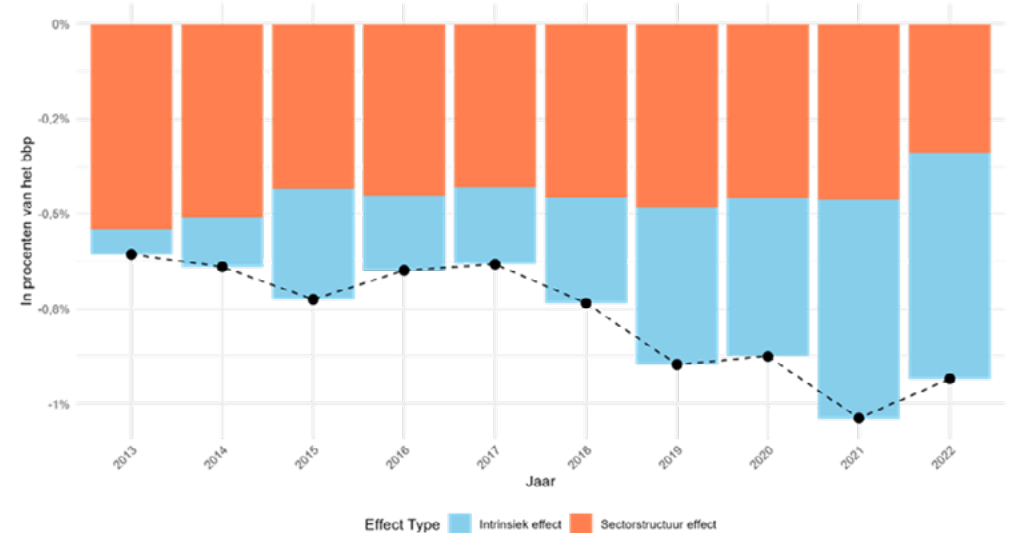


Figure 14: Sectoral structure and intrinsic private R&D gap in the Netherlands, compared with a benchmark of OECD countries with above-average R&D intensity (Source: TNO, 2025c).

In-depth analyses show that the machinery industry, agriculture, and the electrical equipment industry perform better than their international counterparts (TNO, 2025b; 2025c). The strong position of the machinery industry is largely attributable to ASML, which plays a dominant role in the Dutch R&D landscape (Geurts, 2024).

Our research also highlights opportunities for Dutch sectors to increase R&D intensity. To further analyse the intrinsic effect, we identified which Dutch sectors invest relatively little in R&D compared with their foreign counterparts. It is precisely these sectors—the pharmaceutical industry, ICT, and specialised business services—that offer significant opportunities to strengthen R&D intensity in the Netherlands (TNO, 2025b; 2025c).

Figure 15 and Table 2 illustrate that, across several innovation intensive sectors, R&D intensity in the Netherlands is lower than in (other) leading EU countries. In particular, the Dutch pharmaceutical industry and the automotive industry invest substantially less in R&D. By contrast, the machinery and equipment industry in the Netherlands exhibits a clearly higher R&D intensity than the benchmark.

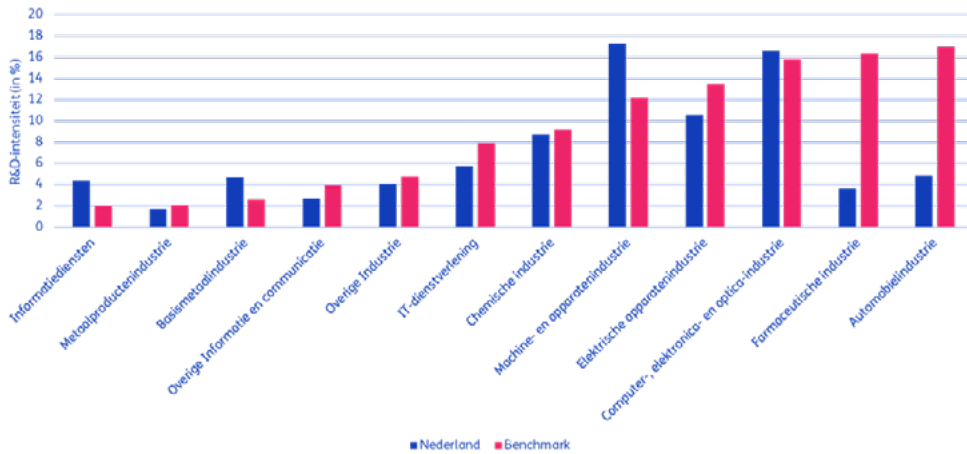


Figure 15: R&D intensity of Dutch sectors compared to an international benchmark (2023) (Source: TNO, 2025b).<sup>3</sup>

R&D-intensiteit sector	Nederland (in %)	Benchmark (in %)	Landen in benchmark	Verschl in R&D-Intensiteit (in procentpunten)
Farmaceutische industrie	3.6	16.4	BE, DK, DE, FI, AT, SE	-12.8
Automobielandustrie	4.9	16.9	BE, DE, FI, AT	-12.1
Elektrische apparatenindustrie	10.6	13.4	BE, DK, DE, FI, AT, SE	2.8
IT dienstverlening	5.8	7.9	BE, DK, DE, FI, IS, AT	2.2
Overige Informatie en communicatie	2.7	4.0	BE, DE, AT, SWE	-1.3
Overige Industrie	4.1	4.8	BE, DK, DE, FI, IS, AT, SE	-0.7
Chemische industrie	8.7	9.2	BE, DK, DE, FI, IS, AT, SE	-0.5
Computer-, elektronica- en optica-Industrie	16.6	15.8	BE, DK, DE, FI, IS, AT, SE	0.8
Basismetalaalindustrie	4.8	2.6	BE, DK, DE, FI, AT, SE	2.2
Informatiediensten	4.3	2.0	BE, DK, DE, FI, IS, AT	2.3
Machine- en apparatenindustrie	17.3	12.1	BE, DK, DE, FI, IS, AT, SE	5.2

Table 2: R&D intensity of Dutch sectors compared to an international benchmark (2023) (Source: TNO, 2025b).

<sup>3</sup> These results have not been adjusted for sectoral structure.

## 4 Enhancing the technological position of the Netherlands

To improve the Netherlands’ technological position, innovation and technology play a key role. To better understand this technological position, it can be linked to the different stages of the innovation chain, as visualised in Figure 16. This innovation chain starts with fundamental research and ends with the large scale diffusion of innovation, that is, the scaling up and commercialisation of developed products. Each stage of this innovation chain relates to a different aspect of the Netherlands’ competitive position. Broadly speaking, a distinction can be made between the knowledge position, the technology position, and the entrepreneurship position.

In the following sections, we analyse each of these aspects on the basis of quantitative data. We focus on the ten key technologies that are central to the National Technology Strategy (NTS; EZK, 2024). This sheds light on where the Netherlands stands at each stage of the innovation chain and which aspects of the process require more attention.

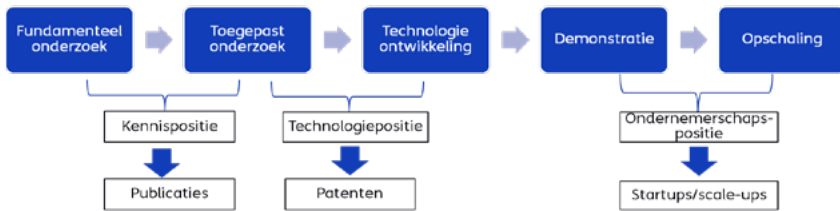


Figure 16: Explanation of the Netherlands’ position within the innovation chain.<sup>4</sup>

<sup>4</sup> Although the innovation chain is depicted here as linear for the sake of simplicity, we recognise that in practice the innovation process is rarely linear and involves continuous feedback loops between the various stages. Furthermore, the innovation process is strongly influenced by various enabling conditions within the broader innovation system – such as regulation, infrastructure and the availability of talent – which are not included in the figure. For further information, see also TNO 2025b.

### 4.1 The knowledge position of the Netherlands is under pressure

This section describes the knowledge position of the Netherlands in the ten NTS technologies (EZK, 2024) over the period 2013–2022, in comparison with 17 countries (EU 15, the United States and China).<sup>5</sup> The knowledge position is assessed on the basis of scientific publication data and relative to these other knowledge intensive economies.

The results, summarised in Figure 17, show that in absolute terms the United States and China dominate the total number of scientific publications within the NTS technologies. The Netherlands ranks in the middle of the European group. However, when scientific productivity (i.e. efficiency; the number of publications per 100 FTE public researchers) is considered, the Netherlands ranks among the top four countries in our selection across all NTS technologies, with the exception of Cybersecurity technologies. The Netherlands is a global leader in scientific productivity in Process technology, including process intensification, Biomolecular and cell technologies, Imaging technologies, Mechatronics and opto mechatronics, and AI & data science.

The Netherlands’ knowledge position is further expressed in terms of scientific citation impact (FWCI) and specialisation (RAI).<sup>6</sup> Across all NTS technologies, the Netherlands demonstrates a moderate to strong relative scientific impact.

In terms of specialisation, the Netherlands is moderately to averagely specialised across the NTS technologies. Only in Biomolecular and cell technologies does the Netherlands show above average specialisation.

Over the period 2013–2022, Dutch citation impact (FWCI) in the NTS technologies shows considerable fluctuation. At the same time, the degree of scientific specialisation (RAI) displays a clear downward trend across the NTS technologies.

These analyses therefore show that while the Netherlands maintains a productive and impactful knowledge position in the NTS technologies, it has become increasingly less specialised than other countries in recent years. Over time, this may undermine the Netherlands’ knowledge position.

<sup>5</sup> This refers to the countries that were already members of the European Union prior to 2004: Belgium, Germany, Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Spain, the United Kingdom and Sweden.

<sup>6</sup> The FWCI shows how often a publication is cited compared to the global average for similar publications. The FWCI is normalised by key technology, so that values across technologies are comparable. The Relative Activity Index (RAI) is used to compare a country’s knowledge strengths and priorities with those of other countries in the same research fields (similar to the Revealed Comparative Advantage measure).

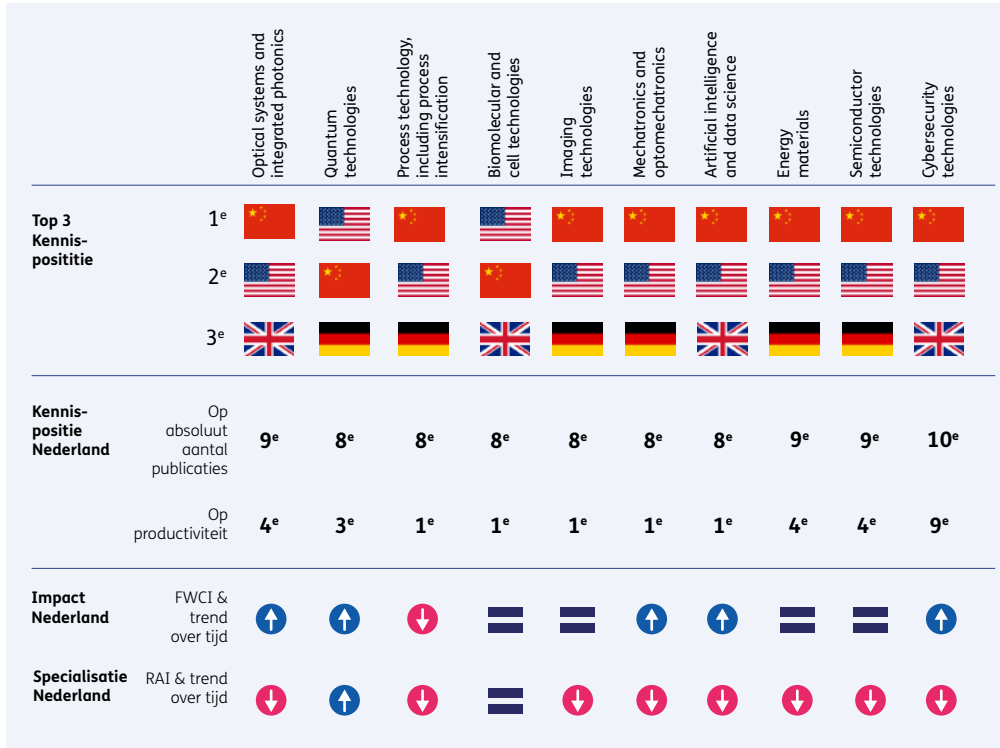


Figure 17: The Dutch knowledge position (Source: TNO Vector).<sup>7</sup>

7 Countries' knowledge standing is based on the absolute number of scientific publications in the period 2013–2022 and in comparison with a group of benchmark countries (EU15, the US and China). These 17 countries together account for 74.8% of scientific publications on the ten NTS technologies. The publication data is sourced from Elsevier (2023). In addition, the number of scientific publications has also been adjusted for the number of full-time equivalent (FTE) public sector researchers within these countries (OECD, 2025), in order to indicate scientific productivity. It is important to note here that this productivity (ranking) is calculated based on the total number of FTE public researchers per country – and thus not specifically per NTS knowledge area – and that the Netherlands generally has a high level of scientific productivity (Rathenau Institute, 2024). The assessment of the Netherlands' scientific impact is based on a combination of the average citation impact (FWCI) and the trend in this impact between 2013 and 2022. The assessment of the Netherlands' scientific specialisation is based on a combination of the average degree of specialisation (RAI, or RCA) and the trend in this specialisation between 2013 and 2022.

## 4.2 The technological position of the Netherlands is under pressure

This section describes the technological position of the Netherlands across the ten NTS technologies over the period 2015–2025. This technological position is assessed on the basis of patent data and patent citation data, and in comparison with other knowledge intensive economies. Figure 22 provides a summary overview of the Netherlands' technological position.

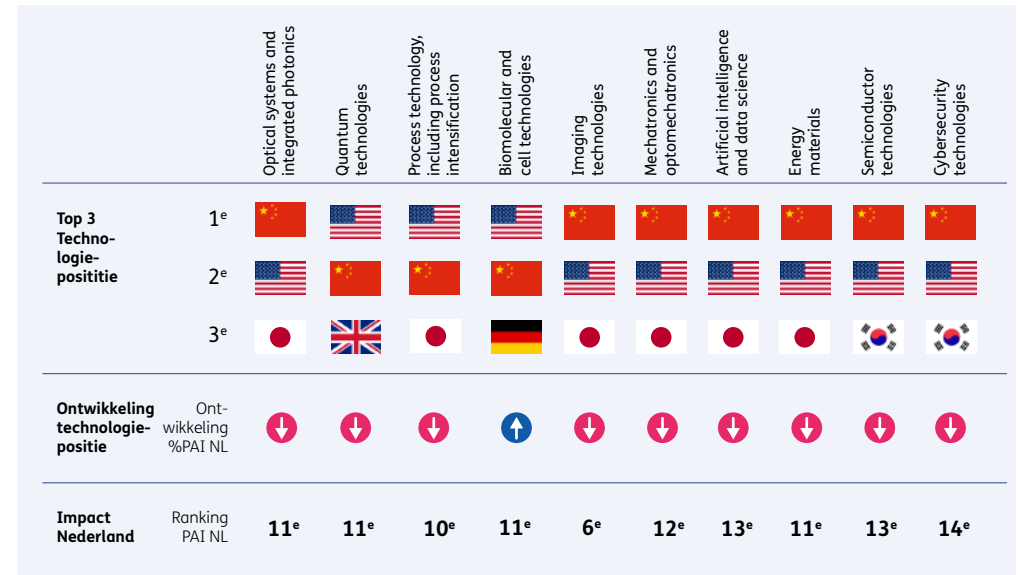


Figure 18: The Dutch technology position (Source: TNO Vector).<sup>8</sup>

8 The technological position is expressed in terms of countries' Patent Asset Index (PAI) contribution. The PAI (see Ernst & Omland, 2011) measures the total value of countries' patent portfolios within a specific technological domain. The index takes into account both the number of patents and the quality of those patents (market coverage and number of citations). The PAI contributions have been calculated using LexisNexis' PatentSight+, based on the number of NTS patent families registered between 2015 and 2025 and already active in November 2025.

**4.2.1 Valuable technological positions in perspective**

Figure 19 shows the geographical distribution of patents based on their size, innovation value and market value (PAI), which together reflect the total value of a patent portfolio. China (approximately 50%) and the United States (approximately 30%) together account for the largest share of the global innovation and market value of NTS patents. As a result, they increasingly shape the direction of technological progress and capture a substantially larger share of the economic value created. European countries play a more limited role in comparison with these frontrunners; within Europe, Germany holds the largest share.



Figure 19: Geographical distribution of NTS patent portfolios by size and innovation and market value (PAI) (Source: TNO Vector).

Figure 20 illustrates the development in the size and impact of countries' NTS patent portfolios worldwide over the past decade. The Netherlands is compared with a set of benchmark countries selected on the basis of their high R&D investments (EZ, 2025). The trend shows strong growth in impact, particularly for China and the United States, which now represent the largest shares—an especially striking development given that these countries were much closer to each other in earlier years. European countries also show growth, but to a more limited extent, resulting in a markedly wider gap in impact between the frontrunners (China and the United States) and the rest than ten years ago.

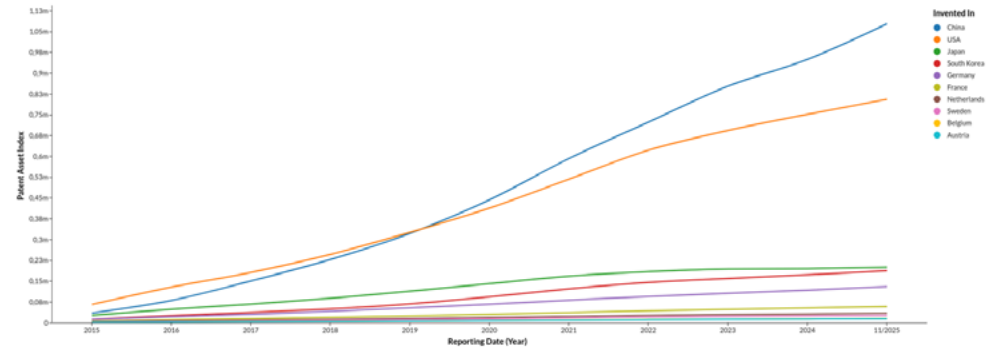


Figure 20: Trends over the past ten years in the size and innovation and market value (PAI) of NTS patent portfolios in Europe (Source: TNO Vector).

Figure 21 zooms in on the development of the size and impact of NTS patent portfolios in a number of European countries over the past ten years. This shows that Germany is the clear frontrunner in both growth and impact, with the gap vis à vis other European countries, including the Netherlands, continuing to widen. The Netherlands exhibits more moderate growth, but nevertheless achieves a higher overall impact than countries such as Sweden, Belgium and Austria. A caveat is that these countries invest more in R&D than the Netherlands (EZ, 2025), which may lead to stronger growth in patents and impact in the future.

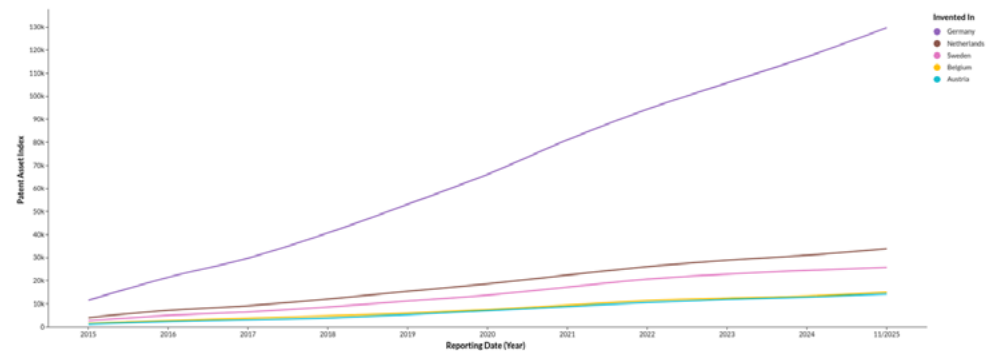


Figure 21: Trends over the past ten years in the size and innovation and market value (PAI) of NTS patent portfolios in Europe (Source: TNO Vector).

**4.2.2. Development of the Netherlands’ technological position**

Figure 22 provides a more detailed picture of the Netherlands’ contribution to global patent value over the past ten years, broken down by the different NTS technology domains. The figure shows that the Dutch technological position exhibits a downward trend in almost all NTS technologies, which may undermine the Netherlands’ technological position in the longer term.

In particular, the contribution in imaging technologies—where the Netherlands was still strongly represented in 2015—shows the most pronounced decline in technological position. Despite this decline, imaging technologies remain the domain in which the Netherlands’ contribution is relatively the largest in 2025.

An exception to the general downward trend is biomolecular and cell technologies, which show a slight upward trend.

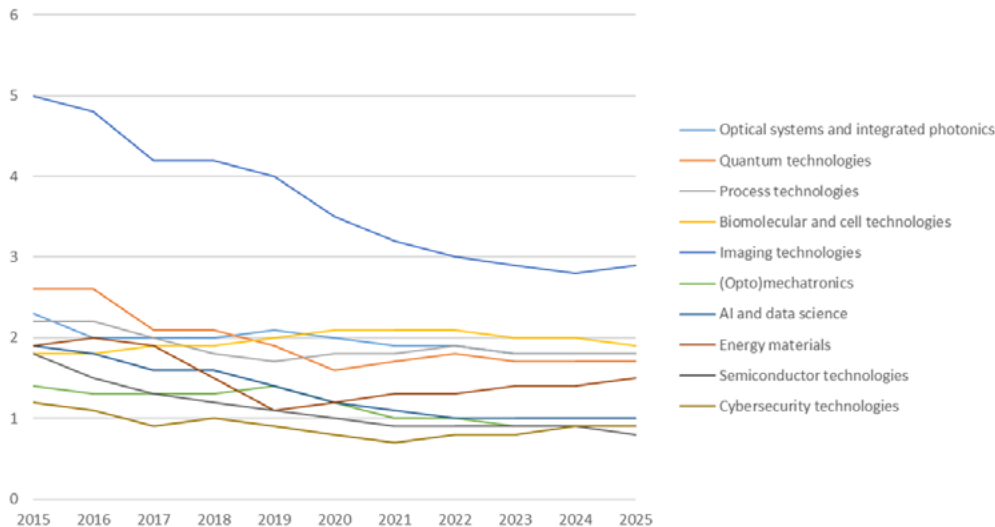


Figure 22: Trend in the Netherlands’ contribution (as a percentage) to the global value of NTS patent portfolios (Source: TNO Vector).

Table 3 provides an overview of the Netherlands’ share of global patent families, as well as rankings in terms of portfolio size and patent impact, and the corresponding increases or decreases.

The table shows that the Dutch share of global NTS patents averages below 1%, with quantum technology as a clear outlier. On average, the Netherlands ranks 11th for this technology in terms of both the number and impact of patents, which is considerably higher than the Netherlands’ 18th position in the ranking of the world’s largest economies (measured by GDP) (IMF Data, 2025). Imaging technologies also stand out positively, with the Netherlands achieving a 6th place.

For most NTS technologies, the Netherlands’ position has remained stable or slightly deteriorated (2021–2025 compared with 2015–2020). While these rankings still present a relatively strong picture in relation to the size of the Dutch economy, the global patent landscape is increasingly dominated by a small number of technological powerhouses, notably the United States and China (see also Figure 19). The Netherlands will therefore need to invest in its technological position to remain relevant in the long term.

	Aandeel aan Patent Families	Ranking obv Portfolio Size (gem. 2015-2025)	Ranking obv PAI (gem. 2015-2025)	Delta T Portfolio Size Ranking*	Delta T PAI Ranking*
Optical systems and integrated photonics	0.77%	10e	11e	-	-
Quantum technologies	2.51%	11e	11e	-	=
Process technologies	0.67%	11e	10e	=	-
Biomoleculair and cell technologies	0.41%	12e	11e	=	-
Imaging technologies	1.42%	6e	6e	=	=
(Opto)mechatronics	0.25%	13e	12e	=	=
AI and data science	0.45%	12e	13e	-	+
Energy materials	0.60%	12e	11e	+	-
Semiconductor technologies	0.35%	13e	13e	-	=
Cybersecurity technologies	0.90%	14e	14e	=	=

Table 3: Development of the Netherlands’ contribution to the global value of NTS patent portfolios (Source: TNO Vector).

#### 4.2.3. Potential in the Netherlands' technological position

Figure 23 shows the relationship between the Netherlands' share of global patent value and the complexity of NTS technologies, providing insight into the degree of imitability and, consequently, the potential to achieve a comparable position. For each NTS technology, the chart displays relative complexity (following Balland & Boschma, 2024) in relation to the Netherlands' share of total global patent value (PAI), with the average degree of specialisation of the Netherlands (RCA) represented by the size of the bubbles.

Figure 23 shows that the Netherlands has a relatively higher patent contribution in three relatively complex NTS technologies—quantum technologies, optical systems and integrated photonics, and imaging technologies—which offers opportunities to further build on these leading positions (upper right quadrant). For the remaining technologies, the Dutch share of global patent value is generally lower (left side of the figure), or concerns technologies that are relatively less complex (lower right quadrant). In these areas, there is a need to establish leading positions and to translate existing knowledge and technological capabilities more effectively into (economic) value.

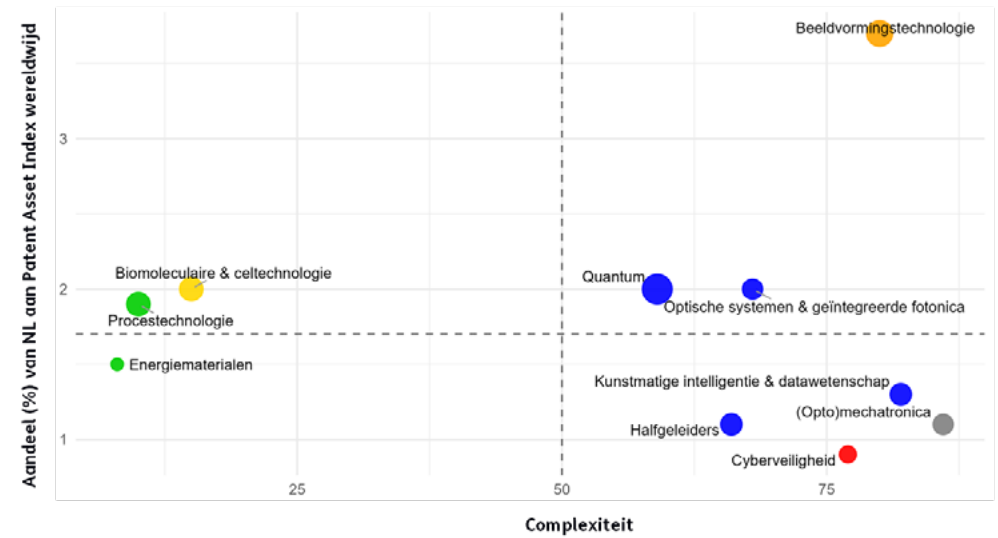


Figure 23: Relationship between the technological complexity of NTS technologies and the Netherlands' contribution to global patent value, where the bubble size represents the RCA (dotted lines:  $x = 50$  (mean),  $y = 1.7$  (median)). Legend: Blue = Digitalisation; Green = Energy & Climate; Yellow = Bio/Med Tech; Red = Security. Grey ((Opto)mechatronics) and Orange (Imaging technology) cannot be directly assigned to a specific focus area (Source: TNO Vector).<sup>9</sup>

<sup>9</sup> The Revealed Comparative Advantage (RCA) measures a country's degree of specialisation in a technological (or economic) domain relative to the global average. The RCA values are calculated based on the number of (NTS) patents in the period 2013–2022 (Elsevier, 2023). A larger sphere indicates a relatively higher level of global specialisation for the Netherlands within this technological domain ( $RCA > 1$  = above-average specialisation).

Figure 24 again presents the technological complexity of the NTS technologies and the Netherlands' degree of specialisation, but now in relation to the citation balance. This indicator provides insight into the extent to which the Netherlands is a net importer or exporter of knowledge based on patent citations, and thus into the degree to which Dutch innovations serve as a foundation for subsequent technological developments elsewhere (Conijn et al., 2026).

Figure 24 shows that, in particular, NTS technologies that align with the focus area of Digitalisation (blue) exhibit relatively strong knowledge exports (upper right quadrant). For these technologies, the Netherlands achieves a more positive citation balance in combination with higher technological complexity, indicating a knowledge base that is more difficult to imitate and a relatively strong international position.

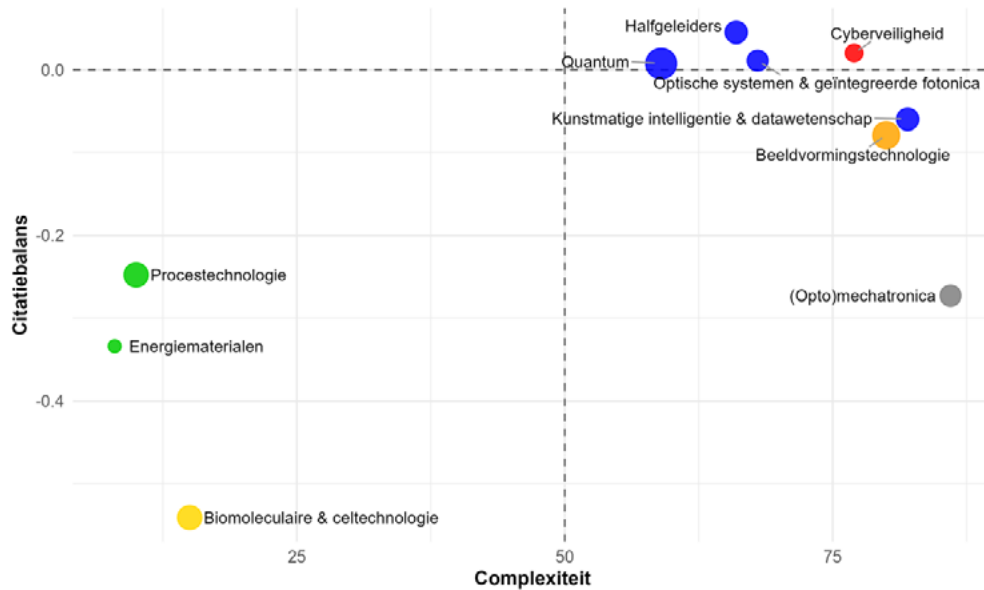


Figure 24: Relationship between the technological complexity of NTS technologies and knowledge import/export (citation balance), with the RCA represented by bubble size (dotted lines: x = 50 (midpoint), y = origin). Legend: Blue = Digitalisation; Green = Energy & Climate; Yellow = Bio/Med Tech; Red = Security. Grey ((Opto-)mechatronics) and Orange (Imaging technology) cannot be assigned to a specific focus area on a one-to-one basis (Source: TNO Vector).

Figure 25 provides an overview with more information on the performance of the NTS technologies with respect to the balance between Dutch knowledge imports and exports, the size and diversity of the countries on which the Netherlands depends, and the degree of institutional similarity between these countries and the Netherlands. Institutional similarity is determined on the basis of the shares of EU, OECD/NATO and other countries from which the Netherlands sources knowledge (Conijn et al., 2026). The figure shows that performance varies considerably: no single technology consistently scores strongly or weakly across all dimensions. This indicates that each NTS technology has its own specific opportunities and vulnerabilities.

Within this variation, several patterns stand out. Process technology exhibits the greatest diversity of knowledge sources, pointing to a broad and varied set of supplier countries and, consequently, a relatively robust knowledge base. Energy materials, by contrast, show the highest degree of institutional similarity, with a clear concentration of knowledge sources within Europe. Semiconductors display the most positive citation balance: countries from which the Netherlands imports knowledge also cite Dutch patents to a significant extent. This points to a more reciprocal and balanced exchange of knowledge.

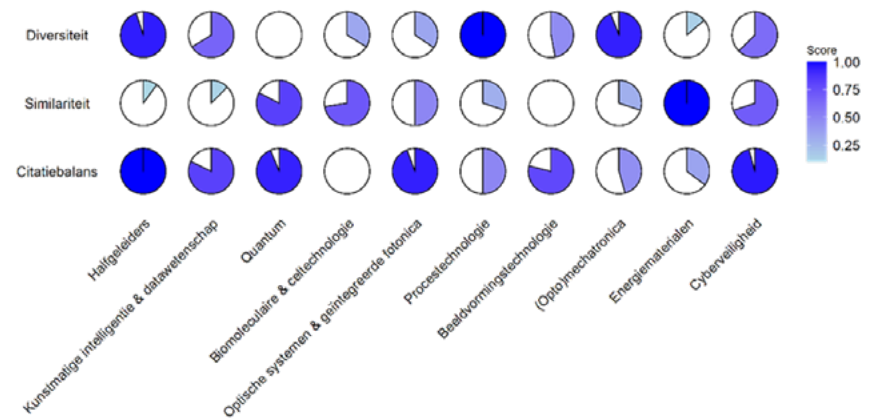


Figure 25: Relative scores of NTS technologies on knowledge import/export, source diversity and institutional agreements with knowledge sources (Source: TNO Vector).

#### 4.2.4. Technological position of organisations

To provide insight into the technological position of international organisations, Figure 26 shows the relationship between the size of patent portfolios held by international organisations (quantity) and the average number of citations received from subsequent patents (quality). The figure shows that the Chinese Academy of Sciences holds a very large number of patents within the NTS technologies, while Apple has a smaller portfolio but is cited more frequently on average. This suggests that Apple’s innovations more often serve as a foundation for further knowledge development, indicating a high level of innovative capacity. In addition, the figure shows that Samsung, overall, possesses the patent portfolio with the highest value, both in quantitative and qualitative terms. This positions Samsung as one of the strongest players in the international technological landscape.

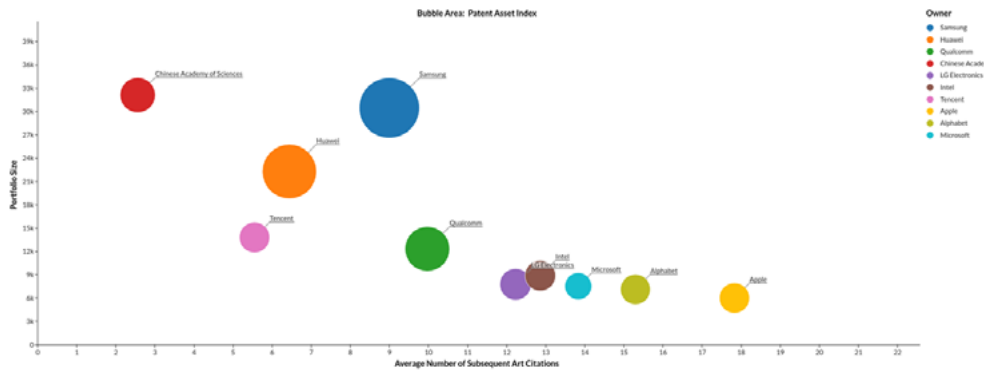


Figure 26: Relationship between the number of patents and the average number of citations from other patents for the top 10 international organisations (based on PAI), where the size of the sphere represents the total patent value (Source: TNO Vector).

Figure 27 also presents the relationship between the quantity and quality of NTS patent portfolios, but focuses specifically on Dutch organisations. This shows that Philips holds the largest number of patents within the NTS technologies, while the patents of ASM International are cited significantly more frequently on average by other patent applications—an indication that subsequent innovations build on this knowledge. Philips, NXP and ASML possess patent portfolios that combine both substantial size and high innovation and market value.

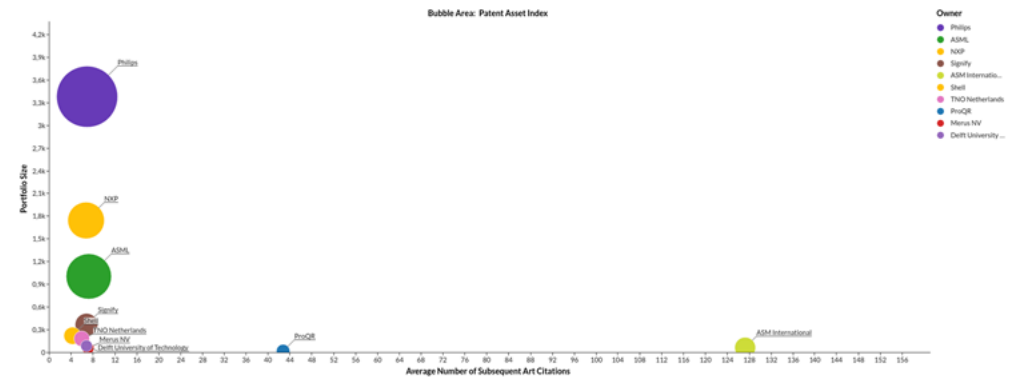


Figure 27: Relationship between the number of patents and the average number of citations from other patents for the top 10 Dutch organisations (based on PAI), where the size of the sphere represents the total patent value (Source: TNO Vector).

### 4.3 The entrepreneurship position of the Netherlands is faltering

To create economic value, developed technologies must be brought to market. This can occur when existing firms add these technologies to their portfolios. More often, however, new technologies are commercially developed by new firms. These startups commercialise emerging technologies and, when successful, grow into potential new control points.

The emergence and scaling up of startups depend on a wide range of factors. Entrepreneurs, for example, require access to test facilities, financing, and skilled personnel (Stam & Van de Ven, 2021). Although the entrepreneurship ecosystem in the Netherlands is reasonably well developed, entrepreneurs continue to face significant challenges when scaling their businesses (McKinsey & Company, 2022), as also described in Chapter 3. High technology sectors face additional, specific challenges, including the difficulty of attracting investors who are willing to take greater risks and do not expect short term returns (Techleap, 2025).

### 4.3.1. Dutch startups and scale-ups

When looking at startups and scale ups, it becomes clear that the Netherlands lags behind in the progression from startups to scale ups (Techleap, 2025; TNO, 2025b; McKinsey & Company, 2022). The Dutch scale up ratio of 21.5%—the share of startups that successfully scale—falls below the European average (23.1%) and is far behind Germany (40.6%) and the United States (54.1%) (Techleap, 2025; see also Figure 28). Figure 29 shows that, across key factors that contribute to improving the scale up ratio—such as access to capital, talent availability and regulation—the Netherlands performs worse than comparable countries (McKinsey & Company, 2022).

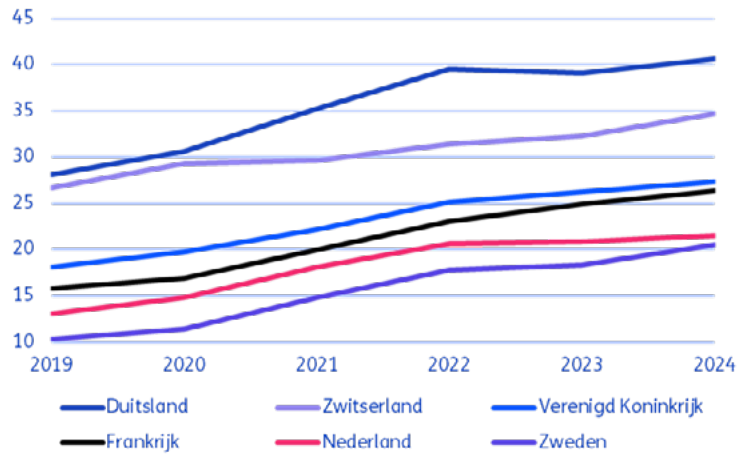


Figure 28: Scale-up ratio for the Netherlands and European peers for the period 2019–2024 (Source: Techleap, 2025; adapted by TNO Vector).

### Scale-up indicators, 2021

● Worse than 20% of peer set average   ● Within 20% of peer set average   ● Better than 20% of peer set average  
 ● Not available

	Sectors and regional scope		Venture capital	Capital	People	Regulation
	Market capitalization of start-ups as share of GDP	Average start-up valuation	Yearly venture capital financing volume per capita	Total financing volume of domestic investors	Share of tech jobs that are hard to fill	Employee stock ownership plans score
Israel	●	●	●	●	●	●
Estonia	●	●	●	●	●	●
US	●	●	●	●	●	●
Sweden	●	●	●	●	●	●
UK	●	●	●	●	●	●
Germany	●	●	●	●	●	●
France	●	●	●	●	●	●
Netherlands	●	●	●	●	●	●

Source: Dealroom; Index Ventures; State of European tech 21, Atomico, Dec 9, 2021; McKinsey analysis

Figure 29: International comparison of scale-up indicators in 2021 (Source: McKinsey & Company, 2022).

### 4.3.2. Dutch startups and scale-ups in quantum and AI

To gain insight into the commercialisation of new technologies, we examine startups and scale ups that bring these technologies to market. In the analysis below, we map the number of startups and scale ups and also assess the amount of funding these companies have raised.

To define startups and scale ups, we follow the definition used by Techleap (2025) in its State of Dutch Tech report. This means that we include only companies that were founded after 1990 and are still active. Startups are defined as companies that have raised less than USD 10 million in funding, while scale ups are companies that have raised more than USD 10 million in funding. The analysis focuses specifically on startups and scale ups operating in the technology domains of quantum technology and artificial intelligence.

Table 4 shows that the Netherlands has a relatively large number of quantum startups compared with the total number of quantum startups worldwide, accounting for approximately 4.6%. This is broadly in line with the Netherlands’ share of quantum scale ups, which stands at 5.5%. When looking at funding shares, the Netherlands performs slightly better for startups, with a share of 6.7%, but performs substantially worse for scale ups, where its share amounts to only 1%.

Table 5 presents the top five countries in terms of startup funding for quantum technology, while Table 6 shows the top five countries in terms of scale up funding for quantum technology. Whereas the Netherlands ranks fifth in terms of startup funding, it ranks only eleventh with respect to scale up funding. Financing—particularly for scale ups—therefore represents a critical challenge for the Netherlands.

	Aantal startups	Funding startups (EUR M)	Aantal scale-ups	Funding scaleups (EUR M)
<b>Nederland</b>	21	30,05	6	124,42
<b>Wereld (excl. Nederland)</b>	435	414,23	104	11.866,92

Table 4: Dutch start-ups and scale-ups in quantum technology compared with the rest of the world (Source: TNO Vector).

Land	Funding startups (EUR M)
<b>Verenigd Koninkrijk</b>	85,25
<b>Amerika</b>	81,37
<b>Frankrijk</b>	39,39
<b>Canada</b>	35,72
<b>Nederland</b>	30,05

Table 5: Top 5 start-up funding rounds in quantum technology (Source: TNO Vector).

Land	Funding scale-ups (EUR M)
<b>Amerika</b>	6.050,60
<b>Verenigd Koninkrijk</b>	1867,46
<b>Canada</b>	889,45
<b>Finland</b>	553,64
<b>Frankrijk</b>	447,77

Table 6: Top 5 scale-up funding in quantum technology (Source: TNO Vector).

Figure 30 shows that the Netherlands has a reasonably large number of quantum start-ups relative to the global total, and that the Netherlands even accounts for a slightly higher proportion of the total number of scale-ups. However, Figure 30 also confirms that the Netherlands does not yet have any major players in the field of quantum computing. Of the scale-ups, 12 companies can be classified as 'unicorns'. These unicorns are mainly located in the US (7) and Canada (2). Finland, Spain and the UK also have one unicorn each.

Figure 31 illustrates the Netherlands' position in quantum technology across the innovation chain. It becomes clear that further down the innovation chain, the Dutch share becomes increasingly smaller. This confirms the existence of a potential innovation paradox or innovation gap in the Netherlands; the Netherlands excels in fundamental and applied research, but struggles to translate knowledge into applications, new sustainable economic activity and economic growth.

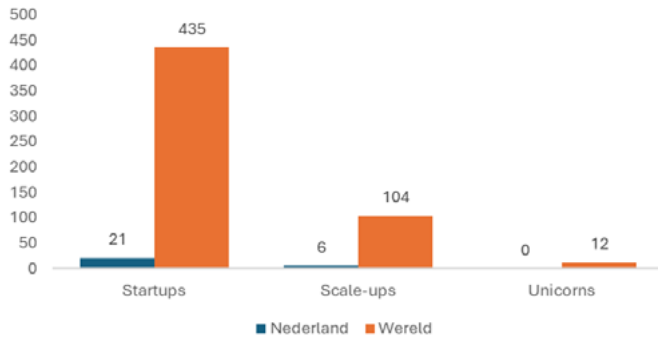


Figure 30: Startups, scale-ups and unicorns in quantum (Source: TNO Vector).

	Wetenschappelijke positie	Technologische positie	Startup / Scale-up financieringspositie
<b>Aandeel Nederland</b>	<b>2,4%</b>	<b>2,0%</b>	<b>1,0%</b>
<b>Beschrijving</b>	Aandeel op basis van aantal quantum publicaties wereldwijd tussen 2013-2022	Aandeel op basis van Nederlandse bijdrage aan wereldwijde quantum PAI in de periode 2015-2025	Aandeel op basis van wereldwijd opgehaalde financiering voor quantum startups en scale-ups in de periode 2020-2024
	<b>Innovatieparadox 1 - Van wetenschappelijke kennis naar toepassing</b> Nederland excelleert in wetenschappelijke output en de kwaliteit van publicaties, maar dit vertaalt zich (nog) niet in een evenredig aantal patenten of nadere toepassingen.	<b>Innovatieparadox 2 - Doorgroei van startups naar scale-ups</b> Nederland heeft moeite om startups structureel door te laten groeien tot grote, impactvolle bedrijven.	

Figure 31: The Netherlands' position in quantum technology based on the percentage of publications, share of patents, and investment in start-ups and scale-ups (Source: TNO Vector).

The figures on AI start-ups and scale-ups paint a similar picture; see Figure 32. Although the Netherlands accounts for almost 3% of global AI start-ups, only 1% of the scale-ups and unicorns are based in the Netherlands. This underlines that transforming start-ups into scale-ups is a challenge. However, it also shows that the Netherlands is capable of producing extremely successful scale-ups, or unicorns.

Figure 33 shows the Netherlands' position in the field of AI technology across the innovation chain. As with quantum technology, the Dutch share becomes increasingly smaller further down the innovation chain; yet another indication of the existence of an innovation paradox in the Netherlands.

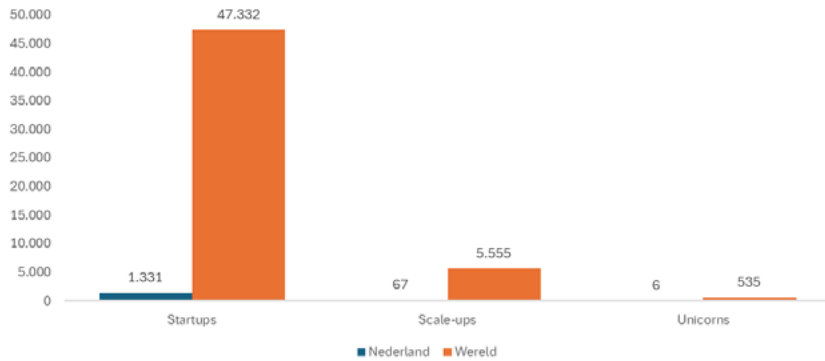


Figure 32: Startups, scale-ups and unicorns in AI (Source: TNO Vector).

	Wetenschappelijke positie	Technologische positie	Startup / Scale-up financieringspositie
<b>Aandeel Nederland</b>	<b>1,3%</b>	<b>1,3%</b>	<b>0,6%</b>
<b>Beschrijving</b>	Aandeel op basis van aantal AI & data science publicaties wereldwijd tussen 2013-2022	Aandeel op basis van Nederlandse bijdrage aan wereldwijde AI & data science PAI in de periode 2015-2025	Aandeel op basis van wereldwijd opgehaalde financiering voor AI startups en scale-ups in de periode 2020-2024
	<b>Innovatieparadox 1 - Van wetenschappelijke kennis naar toepassing</b> Nederland excelleert in wetenschappelijke output en de kwaliteit van publicaties, maar dit vertaalt zich (nog) niet in een evenredig aantal patenten of nadere toepassingen.		<b>Innovatieparadox 2 - Doorgroei van startups naar scale-ups</b> Nederland heeft moeite om startups structureel door te laten groeien tot grote, impactvolle bedrijven.

Figure 33: The Netherlands' position in AI technology based on the percentage of publications, share of patents, and investment in start-ups and scale-ups (Source: TNO Vector).

#### 4.3.3. Economic potential of the Netherlands

In addition to developing potential new economic activity in the Netherlands, the competitive position is also influenced by what existing companies produce. What the Netherlands produces and, in particular, exports says something about its current competitive position in the international market. Furthermore, the more complex a production process or a product is, the more difficult it is to copy that process or product, and the stronger the competitive position is. Trade data can provide insight into this. Trade flows provide a picture of the products in which the Netherlands is strong globally (high market share) and how unique these products are (to what extent other countries can also produce them).

Trade data can be used not only to analyse the current position but also to provide insight into products that are of interest for diversification. Based on the current products produced by the Netherlands, a calculation can be made based on complexity (making imitation more difficult), distance (the extent to which products already produced by the Netherlands resemble the new product) and 'opportunity gain' (how many new products with high complexity are linked to the product). Based on a combination of these three characteristics, the best opportunities can be identified. These are not necessarily products that the Netherlands does not currently produce at all, but products where there is still much to be gained if the Netherlands were to specialise further (Hausmann et al., 2013).

Trade data was therefore used to examine the products that the Netherlands exports. Table 7 shows the Netherlands' top 10 export products. This table demonstrates that the Netherlands holds a leading position in the field of plants and seeds. Agriculture also features prominently, as do various materials such as paper and linoleum. In the current top ten, there is as yet little evidence of the technologies outlined in the National Technology Strategy (EZK, 2024). Furthermore, many of these products have a low level of complexity, with a product complexity score below zero, indicating that these products are less complex than average.

Product	Waarde van export (USD)	Waarde van import (USD)	Marktaandeel	Relatief concurrentievoordeel (1 is neutraal)	Product complexiteit (0 is gemiddeld)
Planten (bollen etc.)	1.389.745.246	100.321.222	0,769689	27,003382	-0,649
Fotografisch papier	170.686.778	4.281.440	0,450387	15,074765	0,341
Planten (stekken)	4.190.804.318	799.815.712	0,421215	14,315304	-1,064
Gesneden bloemen	3.684.870.063	793.046.621	0,408589	13,713144	-1,583
Linoleum	94.106.772	23.310.441	0,361261	12,127198	0,027
Dierlijke vetten	156.018.468	100.806.299	0,337974	11,30675	0,136
Papier en karton	188.710.886	16.255.623	0,29487	9,877172	0,807
Bladmuziek	21.162.869	3.136.547	0,273159	9,58333	1,292
Biobrandstof	7.043.147.771	5.119.343.146	0,263275	8,83103	0,509
Zaden	2.154.346.063	677.330.293	0,260715	8,770762	-0,8

Table 7: The Netherlands' top 10 export products (Source: TNO Vector).

Trade data can also be used to assess the complexity of the products a country exports. Table 8 shows the top 10 most complex export products from the Netherlands. The most complex products currently produced by the Netherlands are industrial goods and processed raw materials. The technologies that feature here are optical systems (photographic products) and semiconductors. In addition, we also see various products linked to composite technologies, but this is not a component of the NTS (EZK, 2024). Of these complex products, only semiconductor machinery, esters and photographic goods also have a relatively large market share.

Product	Waarde van export (USD)	Waarde van import (USD)	Marktaandeel	Relatief concurrentievoordeel (1 is neutraal)	Product complexiteit (0 is gemiddeld)
Fotografische platen en folie	12.254.524	36.697.189	0,00682	0,302829	2,775
Nikkel	15.279.191	29.494.198	0,007058	0,237465	2,559
Textielmachines	1.993.330	610.164	0,001621	0,054421	2,455
Semiconductor machines	22.591.569.750	2.937.768.301	0,205752	7,221507	2,405
Fotografische goederen	243.579.945	112.052.273	0,041939	1,497927	2,399
Cermets (composit van metaal en keramiek)	2.171.113	18467278	0,002405	0,081705	2,126
Gereedschap van cermet	383.801.773	532.693.031	0,017821	0,609973	2,09
Roestvrij staal	28.234.852	24.469.396	0,016514	0,696152	2,079
Metaal met zilver	238.384	667.519	0,002044	0,071703	2,046
Ester (fosfaor en zouten)	51.112.659	62.526.849	0,056096	1,91308	1,999

Table 8: Top 10 complex export products from the Netherlands (Source: TNO Vector).

Based on the Netherlands’ current production levels, as evidenced by trade data, we can examine the opportunities for diversification. The key here is to diversify with new products that are related to existing products (as the production know-how is already in place), that are complex (and therefore offer a better competitive advantage) and preferably also related to other complex products. Based on these three characteristics, the most promising new export products can be identified (see also Hausmann et al., 2013).

Initial analyses show that the Netherlands’ most promising products can be linked to various technologies covered by the NTS (EZK, 2024). This is particularly true in the fields of optical systems (photographic chemicals, microscopes, X-ray machines), semiconductor technology (silicon) and biomolecular technology (vaccines). These are therefore products in which the Netherlands can still grow and where a strong competitive position can be established, as the Netherlands already possesses capabilities in these areas upon which it can build.

## 5 Conclusion: from a faltering engine to a boosted capacity for innovation

### 5.1 Summary

Whilst Europe as a whole faces major challenges regarding its competitiveness, partly due to the dominant positions of China and the US, the Netherlands has its own, specific bottlenecks. The structural shortage of technical talent, the lagging and ever-increasing concentration of corporate R&D investment, and the limited added value in knowledge-intensive sectors are placing an increasingly heavy burden on our future earning capacity.

Innovation, as the driving force behind our future earning capacity, is under increasing pressure – particularly in the longer term. The Netherlands' knowledge and technology position is showing a downward trend, which is evident in the declining share of publications and patents in the key technologies of the National Technology Strategy (EZK, 2024). It is precisely these technologies, linked to crucial sectors such as security, climate & energy, health & biotech and digital technologies, that should be the areas in which the Netherlands excels internationally.

Although the Netherlands has a strong start-up ecosystem and, in the fields of AI and quantum computing, even has a relatively large number of young companies, the transition to scale-ups is also stalling. The lack of larger funding rounds and the shortage of technically skilled personnel are hindering the scaling up of radical innovation and new technology-driven business activity. These inhibiting factors contribute to the so-called innovation paradox: the Netherlands excels in fundamental and applied research, but struggles to translate knowledge into applications, new sustainable business activity and economic growth. The stages in the innovation chain – from scientific publications to patents and subsequently to entrepreneurship – show a visible decline in the Dutch share.

The sectoral structure also plays an important role in this regard. Low-tech products and sectors with relatively low growth in value added are over-represented in the Netherlands, whilst only a limited number of high-tech sectors are performing strongly. Furthermore, Dutch companies consistently invest less in R&D than their international competitors within the same sectors, which puts the technological lead under further pressure. At the same time, there are clear opportunities to significantly scale up the production and export of high-value technology products – such as medical imaging equipment, vaccines or photonic chips.

### 5.2 change of direction is needed to remain competitive

The message is therefore clear: the Netherlands cannot rest on its laurels. A break with current trends is needed to remain competitive in a rapidly changing world. To strengthen the Netherlands' competitive position in the long term, it is not enough to simply repair the faltering innovation engine. Instead, innovation capacity must be stepped up: targeted intensification in key technologies, increasing R&D intensity in promising sectors, and creating conditions in which radical innovations and new business activity can flourish. This requires a stronger culture of innovation and entrepreneurial infrastructure, more experimental development and demonstration, better financing options for technology scale-ups, and addressing the shortage of technical talent (TNO Vector, 2025b). Such targeted investments contribute to strengthening the Netherlands' technological position.

Making choices is crucial in this regard. It is precisely by focusing on a number of knowledge-intensive sectors that the Netherlands can establish unique and valuable control point positions, such as those we already hold in the semiconductor value chain (TNO Vector, 2024b). A solid evidence base regarding the Netherlands' position across the entire innovation chain – some of the building blocks of which are presented in this report – provides guidance for making these choices about building unique, hard-to-imitate knowledge and (international) positions for the Netherlands.

Only if all parts of the innovation chain function and are interconnected can the Netherlands' innovation engine be a successful driver of prosperity.

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## 7 Appendixes

### Appendix 7.1 – Knowledge position

The analyses of the knowledge position were carried out using scientific publication data from Elsevier (2013–2022). Elsevier uses a selection of benchmark countries: EU15, the US, and China.

Indicators:

- **Absolute:** This reflects the total number of scientific publications within the NTS technologies.
- **Scientific productivity (or efficiency):** This reflects the number of publications per 100 FTE public sector researchers. Note: productivity is expressed based on the total number of public sector researchers per country, not specifically per discipline/NTS.
- **Scientific citation impact (FWCI)** measures the influence of scientific research by examining how often publications are cited in other scientific publications. Note: The FWCI is normalised per key technology, so that the values between technologies are comparable. This metric has been used to estimate the ‘impact of Dutch scientific research, expressed in publications’ and its development over time.
- **The Relative Activity Index (RAI)** is used to compare a country’s areas of strength and priorities with those of other countries in the same fields of research. The RAI is the same measure as the Revealed Comparative Advantage (RCA) used in patent analyses, but is applied here to scientific publications. This measure has been used to assess the ‘specialisation of Dutch scientific research, as expressed in publications’ and its development over time.

**7.1.1 Optical systems and integrated photonics**

The Netherlands has a productive and influential position in this NTS technology, but in recent years has specialised in it to a lesser extent than other countries, which could undermine its position in the long term.

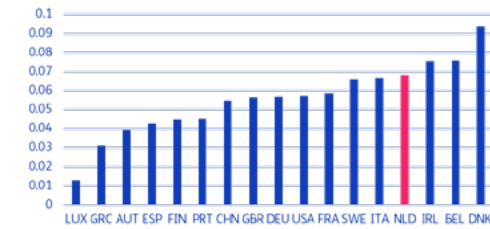
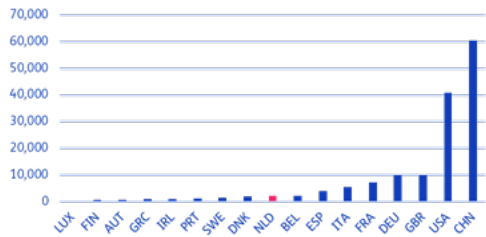


Figure 34: Total number of scientific publications, 2013-2022, in the field of optical systems and integrated photonics (Source: TNO Vector).

Figure 35: Total number of scientific publications per 100 full-time public researchers, 2013-2022, in the field of optical systems and integrated photonics (Source: TNO Vector).

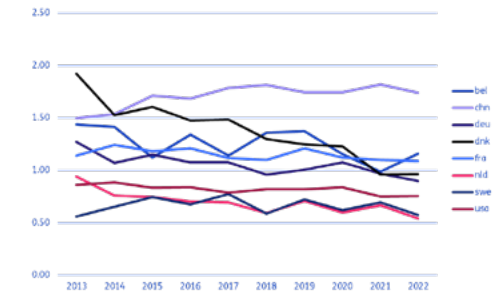
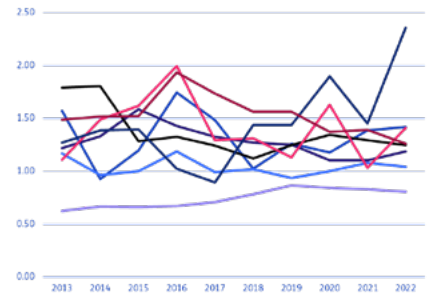


Figure 37: Development scientific impact of publications (FWCI) over time, 2013-2022, in the field of optical systems and integrated photonics (Source: TNO Vector).

Figure 38: Development scientific specialisation (RAI) over time, 2013-2022, in the field of optical systems and integrated photonics (Source: TNO Vector).

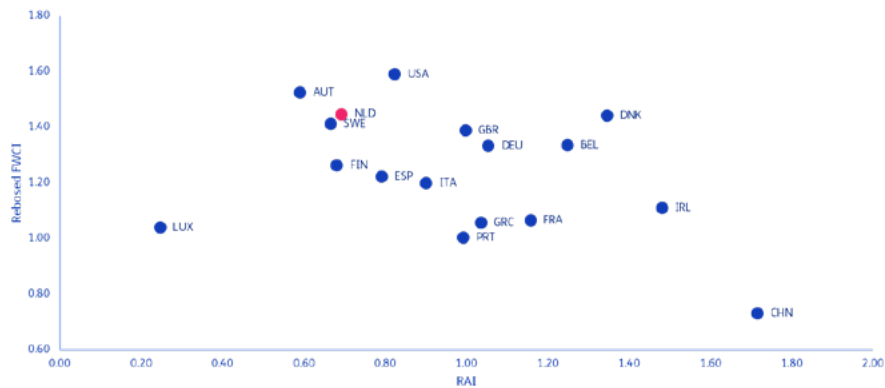


Figure 36: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of optical systems and integrated photonics (Source: TNO Vector).

### 71.2 Quantum technologies

The Netherlands has a productive, influential and specialised position in this NTS technology. In recent years, this influence and specialisation have grown, which could further strengthen the country's position in the long term.

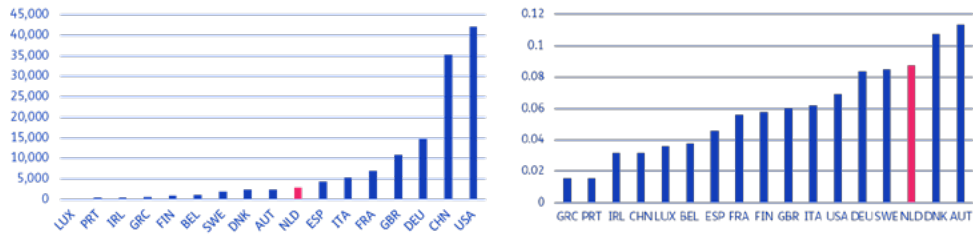


Figure 39: Total number of scientific publications, 2013-2022, in the field of quantum technologies (Source: TNO Vector).

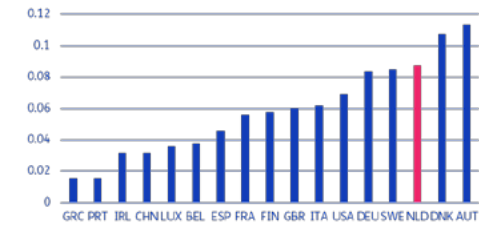


Figure 40: Total number of scientific publications per 100 fte public researchers, 2013-2022, in the field of quantum technologies (Source: TNO Vector).

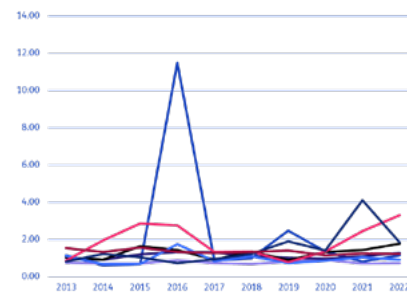


Figure 42: Development scientific impact (FWCI) over time, 2013-2022, in the field of quantum technologies (Source: TNO Vector).

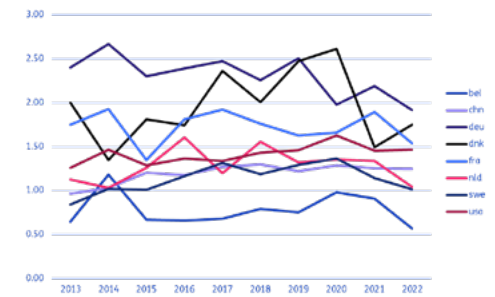


Figure 43: Development scientific specialisation (RAI) over time, 2013-2022, in the field of quantum technologies (Source: TNO Vector).

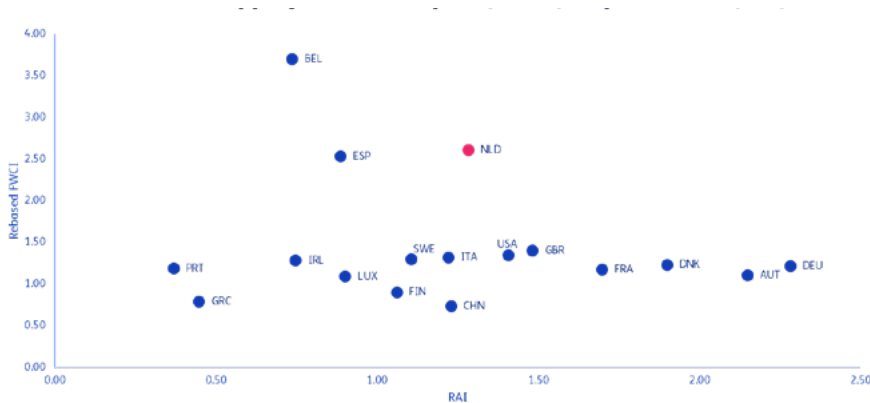


Figure 41: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of quantum technologies (Source: TNO Vector).

**71.3. Process technology, including process intensification**

The Netherlands holds a leading position (No. 1) and possesses reasonably influential and specialised expertise in this NTS technology, but the impact and level of specialisation have been declining in recent years, which could undermine its position in the long term.

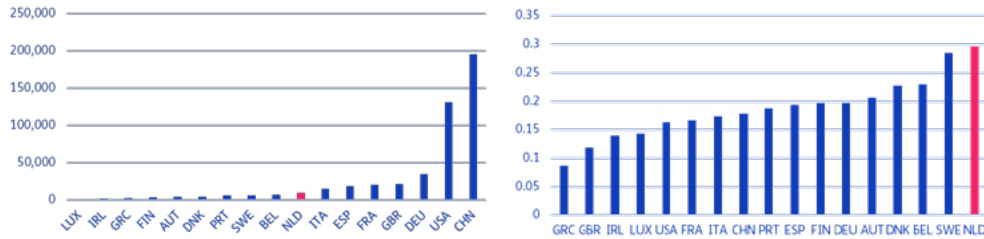


Figure 44: Total number of scientific publications, 2013-2022, in the field of process technologies (Source: TNO Vector).

Figure 45: Total number of scientific publications per 100 fte public researchers, 2013-2022, in the field of process technologies (Source: TNO Vector).

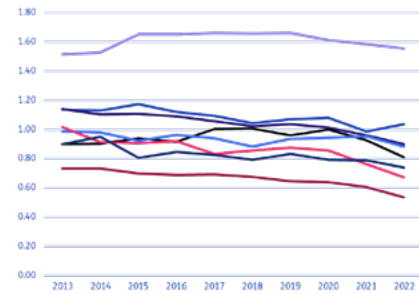


Figure 47: Development scientific impact (FWCI) over time, 2013-2022, in the field of process technologies (Source: TNO Vector).

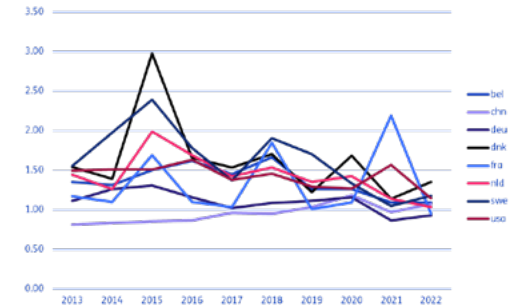


Figure 48: Development scientific specialisation (RAI) over time, 2013-2022, in the field of process technologies (Source: TNO Vector).

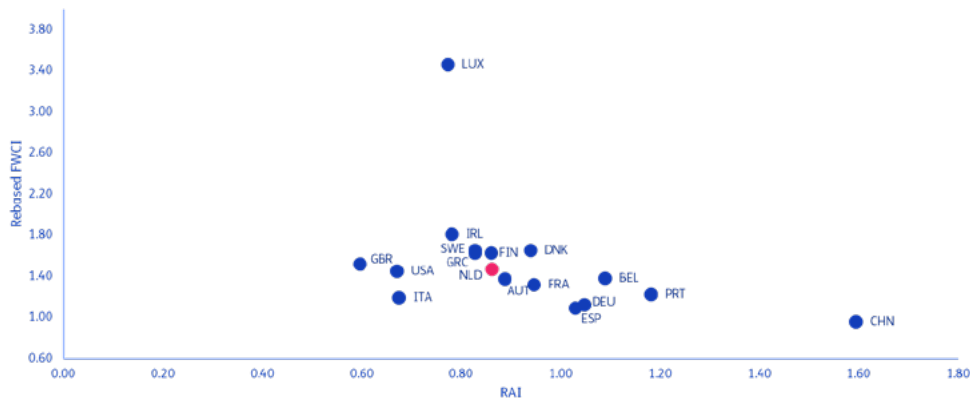


Figure 46: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of process technologies (Source: TNO Vector).

**71.4. Biomolecular and cell technologies**

The Netherlands holds a leading (No. 1) position, specialising in this NTS technology and exerting a significant influence, but this specialisation has been declining in recent years, which could undermine its position in the long term.

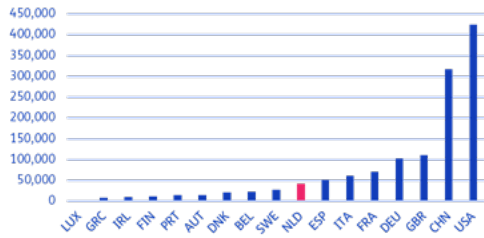


Figure 49: Total number of scientific publications, 2013-2022, in the field of biomolecular and cell technologies (Source: TNO Vector).

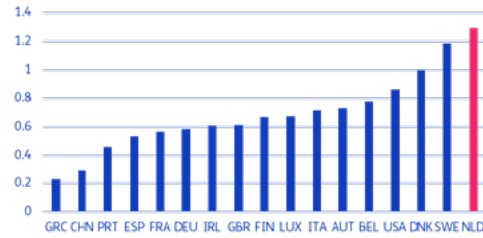


Figure 50: Total number of scientific publications per 100 full-time public researchers, 2013-2022, in the field of biomolecular and cell technologies (Source: TNO Vector).

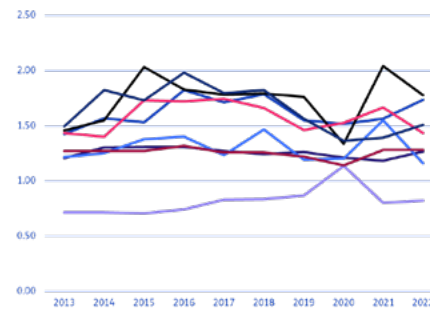


Figure 52: Development scientific impact (FWCI) over time, 2013-2022, in the field of biomolecular and cell technologies (Source: TNO Vector).

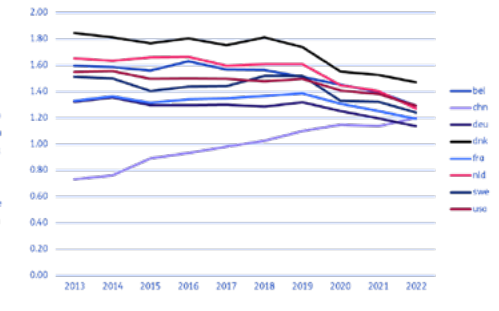


Figure 53: Development scientific specialisation (RAI) over time, 2013-2022, in the field of biomolecular and cell technologies (Source: TNO Vector).

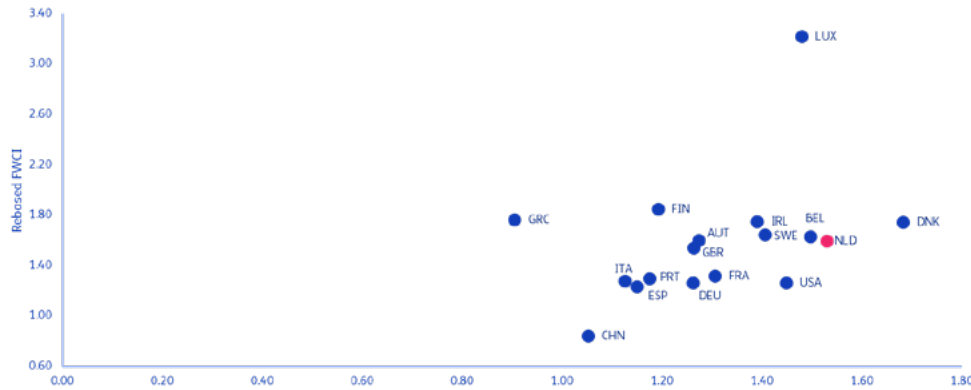


Figure 51: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of biomolecular and cell technologies (Source: TNO Vector).

### 7.1.5 Imaging technologies

The Netherlands holds a leading position (No. 1) and has a moderately influential and specialised knowledge base in this NTS technology, but in recent years it has been specialising in this area to a lesser extent than other countries, which could undermine its knowledge base in the long term.

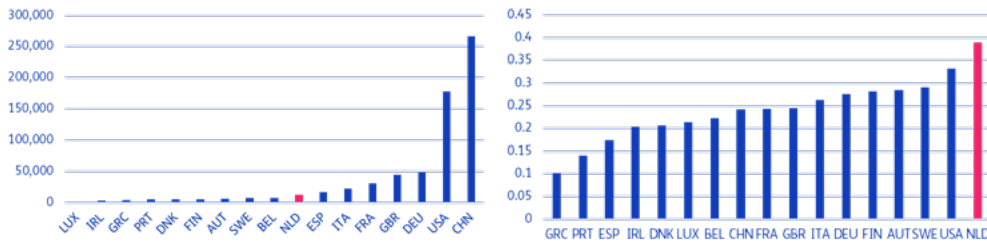


Figure 54: Total number of scientific publications, 2013-2022, in the field of imaging technologies (Source: TNO Vector).

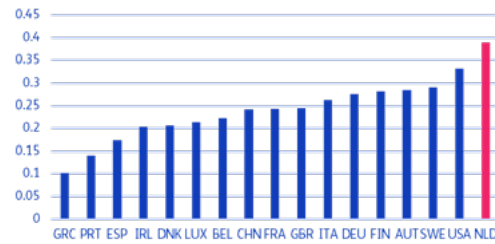


Figure 55: Total number of scientific publications per 100 fte public researchers, 2013-2022, in the field of imaging technologies (Source: TNO Vector).

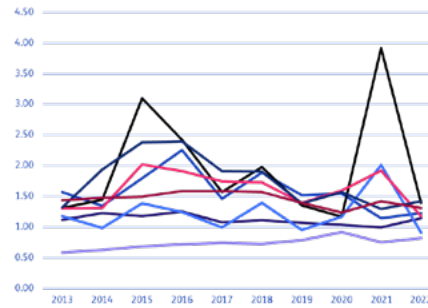


Figure 57: Development of scientific impact (FWCI) over time, 2013-2022, in the field of imaging technologies (Source: TNO Vector).

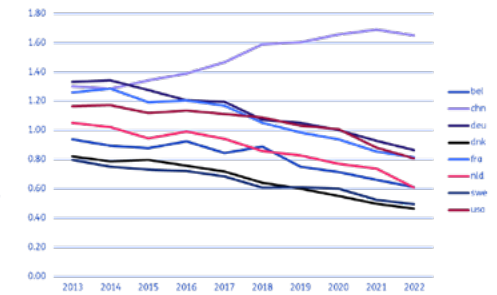


Figure 58: Development of scientific specialisation (RAI) over time, 2013-2022, in the field of imaging technologies (Source: TNO Vector).



Figure 56: Average scientific citation impact (FWCI) and specialization (RAI), 2013-2022, in the field of imaging technologies (Source: TNO Vector).

**71.6. Mechatronics and opto-mechatronics**

The Netherlands holds a leading (No. 1) and influential position in this NTS technology, but its level of specialisation in this field is below average. This specialisation has also been declining in recent years, which could undermine its position in the long term.

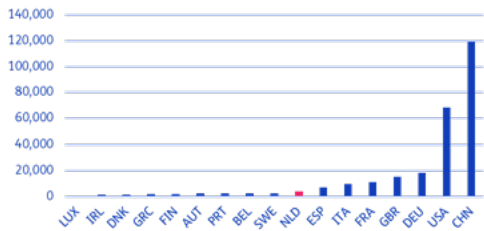


Figure 59: Total number of scientific publications, 2013-2022, in the field of mechatronics and opto-mechatronics (Source: TNO Vector).

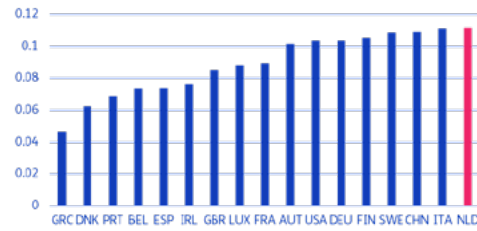


Figure 60: Total number of scientific publications per 100 fte public researchers, 2013-2022, in the field of mechatronics and opto-mechatronics (Source: TNO Vector).

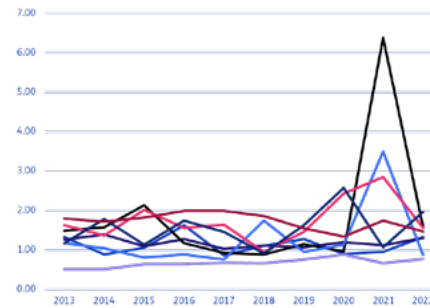


Figure 62: Development of scientific citation impact (FWCI) over time, 2013-2022, in the field of mechatronics and opto-mechatronics (Source: TNO Vector).

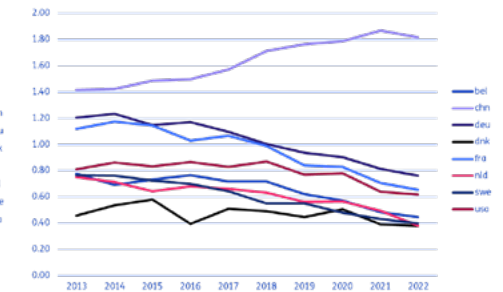


Figure 63: Development of scientific specialisation (RAI), 2013-2022, in the field of mechatronics and opto-mechatronics (Source: TNO Vector).

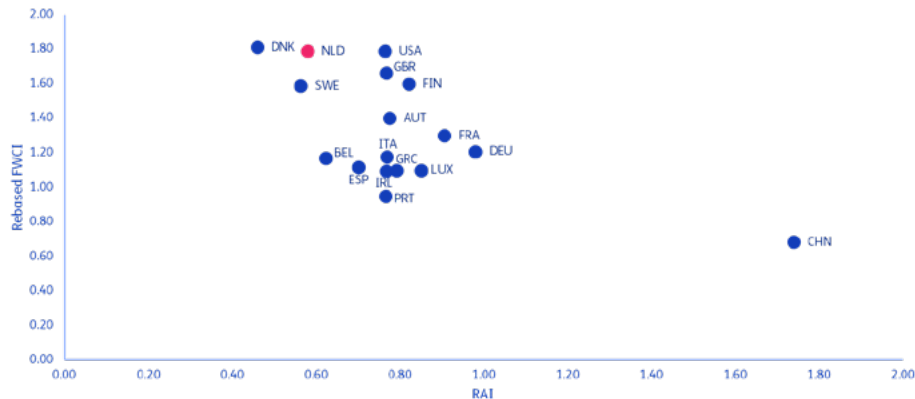


Figure 61: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of mechatronics and opto-mechatronics (Source: TNO Vector).

**7.1.7 Artificial intelligence and data science**

The Netherlands holds a leading (No. 1) position in terms of productivity, impact and specialist expertise in this NTS technology, but in recent years has been specialising in this area to a lesser extent than other countries, which could undermine its position in the long term.

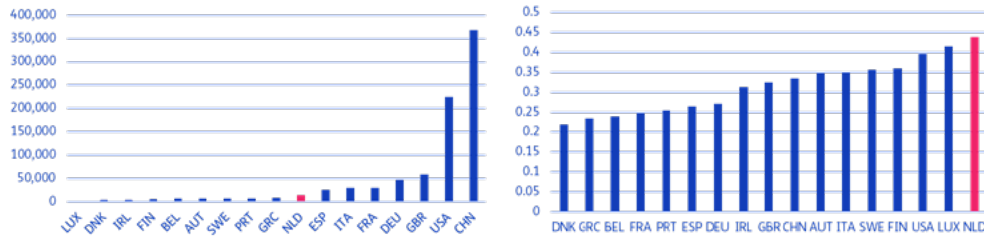


Figure 64: Total number of scientific publications, 2013-2022, in the field of AI and data science (Source: TNO Vector).

Figure 65: Total number of scientific publications per 100 researchers, 2013-2022, in the field of AI and data science (Source: TNO Vector).

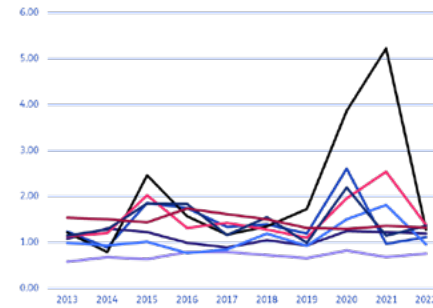


Figure 67: Development of scientific impact (FWCI) over time, 2013-2022, in the field of AI and data science (Source: TNO Vector).

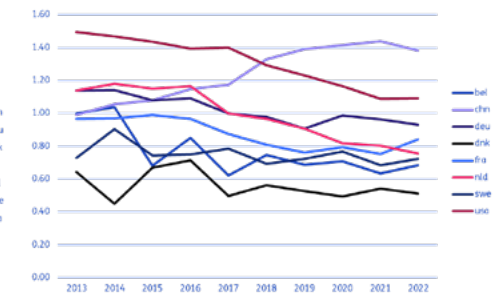


Figure 68: Development of scientific specialisation (RAI) over time, 2013-2022, in the field of AI and data science (Source: TNO Vector).

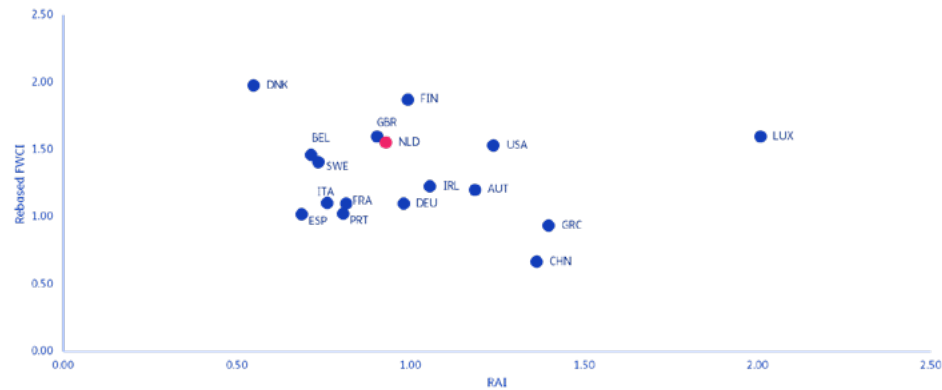


Figure 66: Development of scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of AI and data science (Source: TNO Vector).

### 71.8 Energy materials

The Netherlands holds a productive and influential position in this NTS technology, but its level of specialisation in this field is below average. In recent years, both the impact and the level of specialisation of the Netherlands in this NTS technology have been declining, which could undermine its position in the long term.

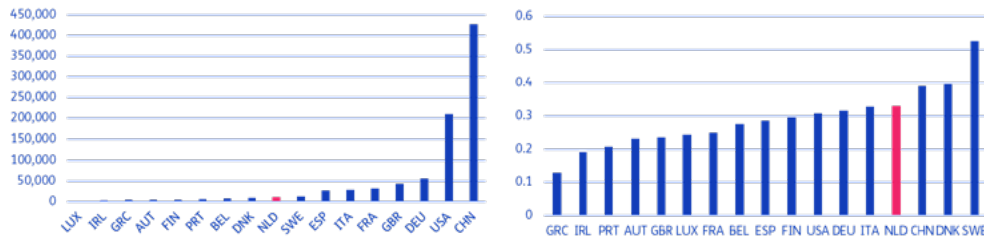


Figure 69: Total number of scientific publications, 2013-2022, in the field of Energy materials (Source: TNO Vector).

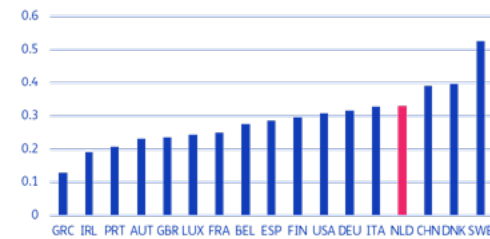


Figure 70: Total number of scientific publications per 100 fte public researchers, 2013-2022, in the field of Energy materials (Source: TNO Vector).

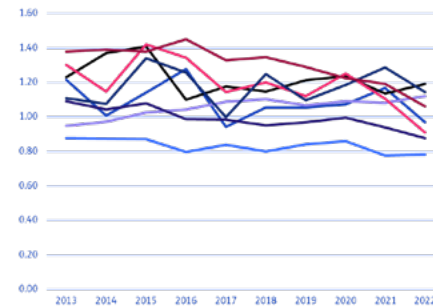


Figure 72: Development of scientific citation impact (FWCI) over time, 2013-2022, in the field of Energy materials (Source: TNO Vector).

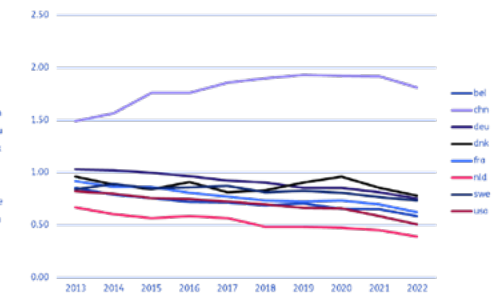


Figure 73: Development of scientific specialisation (RAI) over time, 2013-2022, in the field of Energy materials (Source: TNO Vector).

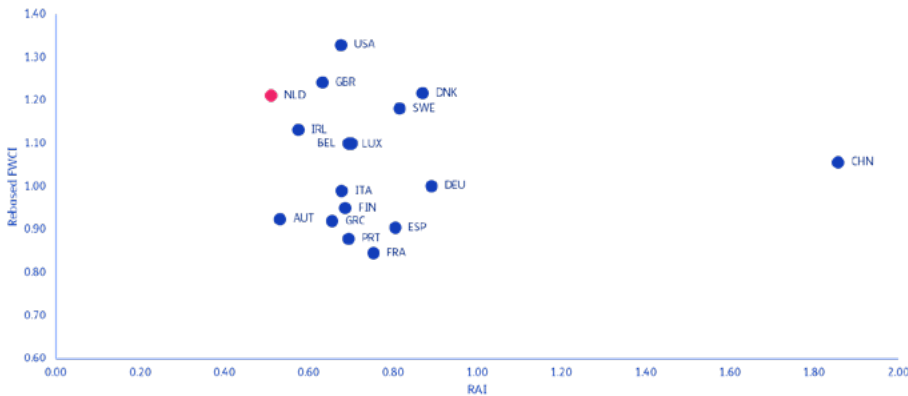


Figure 71: Development of scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of Energy materials (Source: TNO Vector).

**7.1.9 Semiconductor technologies**

The Netherlands has a productive and influential position in this NTS technology, but its level of specialisation in this field is below average. In recent years, both the impact and the level of specialisation of the Netherlands in this NTS technology have been declining, which could undermine its position in the long term.

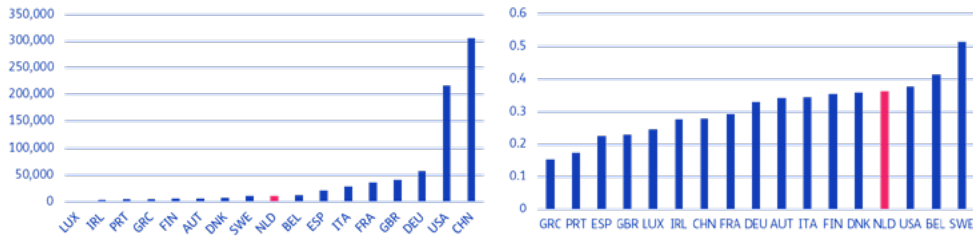


Figure 74: Total number of scientific publications, 2013-2022, in the field of semiconductor technologies (Source: TNO Vector).

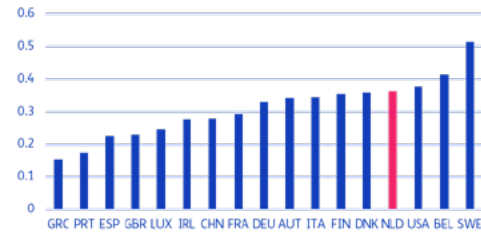


Figure 75: Total number of scientific publications per 100 full-time public researchers, 2013-2022, in the field of semiconductor technologies (Source: TNO Vector).

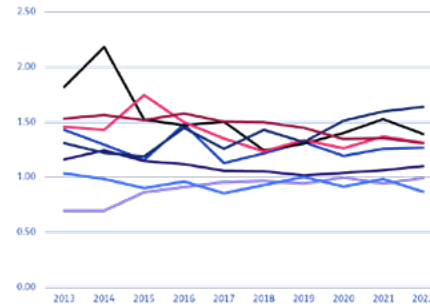


Figure 77: Development of scientific citation impact (FWCI) over time, 2013-2022, in the field of semiconductor technologies (Source: TNO Vector).

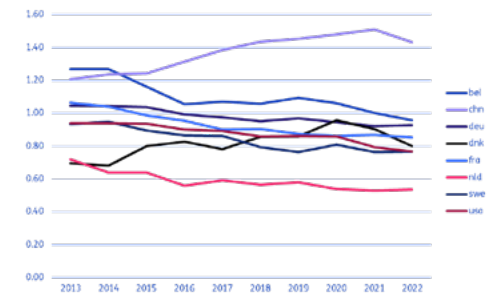


Figure 78: Development of scientific specialisation (RAI) over time, 2013-2022, in the field of semiconductor technologies (Source: TNO Vector).



Figure 76: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of semiconductor technologies (Source: TNO Vector).

### 7.1.10 Cybersecurity technologies

The Netherlands holds an impactful and reasonably productive knowledge position in this NTS technology, but specializes in it below average. In recent years, both the impact and the specialization of the Netherlands in this NTS technology have declined (slightly), which could undermine the knowledge position in the long term.

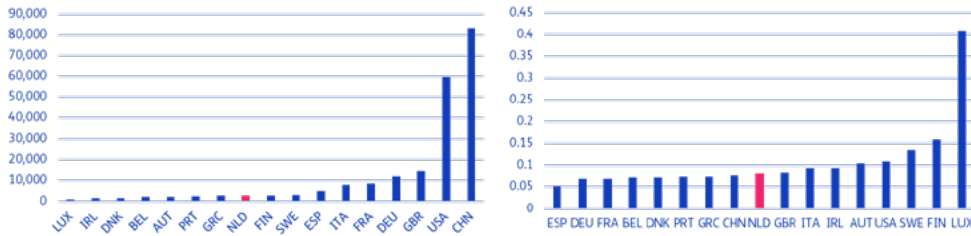


Figure 79: Total number of scientific publications, 2013-2022, in the field of cybersecurity technologies (Source: TNO Vector).

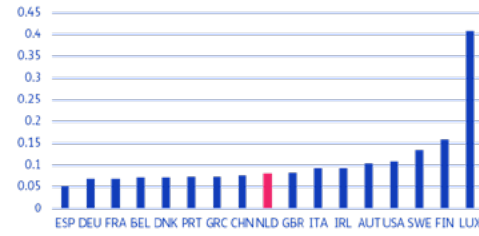


Figure 80: Total number of scientific publications per 100 full-time public researchers, 2013-2022, in the field of cybersecurity technologies (Source: TNO Vector).

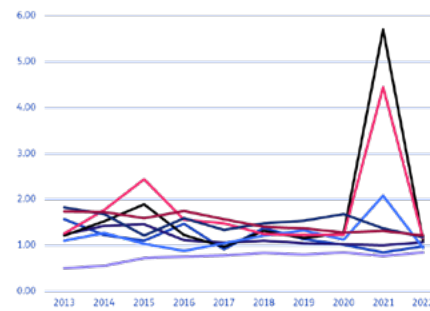


Figure 82: Development of scientific citation impact (FWCI) over time, 2013-2022, in the field of cybersecurity technologies (Source: TNO Vector).

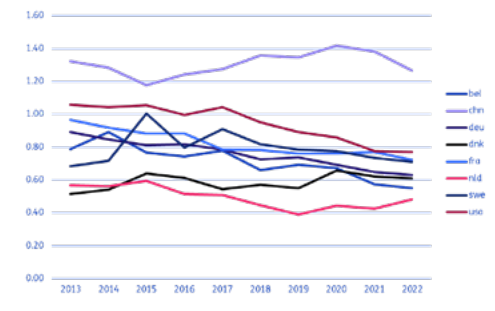


Figure 83: Development of scientific specialisation (RAI) over time, 2013-2022, in the field of cybersecurity technologies (Source: TNO Vector).

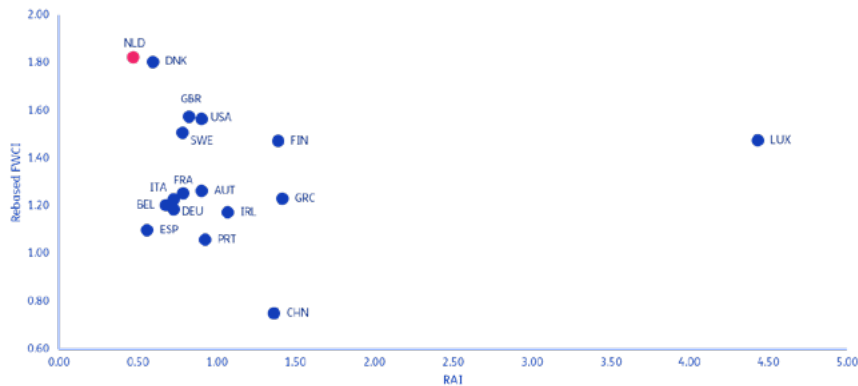


Figure 81: Average scientific citation impact (FWCI) and specialisation (RAI), 2013-2022, in the field of cybersecurity technologies (Source: TNO Vector).

## Appendix 7.2 – Technology position

Patent analyses are used to assess the Netherlands' technological position. This method provides insight into which technologies can deliver the greatest competitive advantage, where the Netherlands is vulnerable due to technological dependencies, and what position the country occupies within global technology networks.

The data used comes from two sources: Lens.org for patent citation data and LexisNexis PatentSight for general patent data, covering the period 2015–November 2025. Comparisons are made with both international (United States, China, Japan and South Korea) and European countries (Austria, Sweden, Belgium and Germany), selected on the basis of their high R&D investment (EZ, 2025).

The analyses focus on the ten NTS technologies. For this purpose, patent codes (IPCs) have been linked to the relevant technology areas, based on the National Technology Strategy (EZK, 2024) and the reassessment of key technologies (Van Bree et al., 2023).

The following indicators are used in the analyses:

- **Portfolio Size** is the number of patent families within a defined patent portfolio (portfolio size)
- **The Patent Asset Index (PAI)** is a measure of the overall strength of a patent portfolio. The PAI reflects the combined technological relevance and market scope of the active patents. Technological relevance is based on both the number and the quality of citations (references by subsequent patents), whilst the market scope indicates in which countries or regions a patent family offers protection. The %PAI represents the Netherlands' share of the global total strength/value of all patent portfolios.
- **Complexity** (Balland & Boschma, 2024) indicates the extent to which a key technology combines multiple competencies, making it difficult to develop and imitate. According to Hidalgo and Hausmann (2009), complexity is determined on the basis of (1) the number of European regions specialising in the technology (fewer regions = higher complexity) and (2) the diversity of technologies in which these regions are active (greater diversity = higher complexity).
- **The Revealed Comparative Advantage (RCA)** index indicates whether a country is more or less active in a particular technological domain than one would expect based on its total patent activity.
- **Incoming and Outgoing Citations** refer only to citations from and to other countries and are averaged across a single patent within a technology. The Citation Balance measures whether a country receives more citations than it gives, on a net basis, adjusted for the

number of countries with which it interacts. This value is then weighted according to a country's share of the total number of citations received, so that larger players in the network carry greater weight (Conijn et al., 2026).

- **Country Diversity** measures both the number of countries cited by the Netherlands and their distribution (Conijn et al., 2026). Institutional Similarity measures the degree of similarity with the Netherlands (where 1 = EU, 2 = OECD/NATO and 3 = other countries) (Conijn et al., 2026).

**Appendix 7.2.1 – Patent citation networks National technology Strategy**

*Technology position the Netherlands: Optical systems & integrated photonics*

- Japan and the United States are identified as key players within this technology domain.
- The Netherlands ranks among the top 10 in this technology domain. The Netherlands is located close to the core cluster of leading countries.

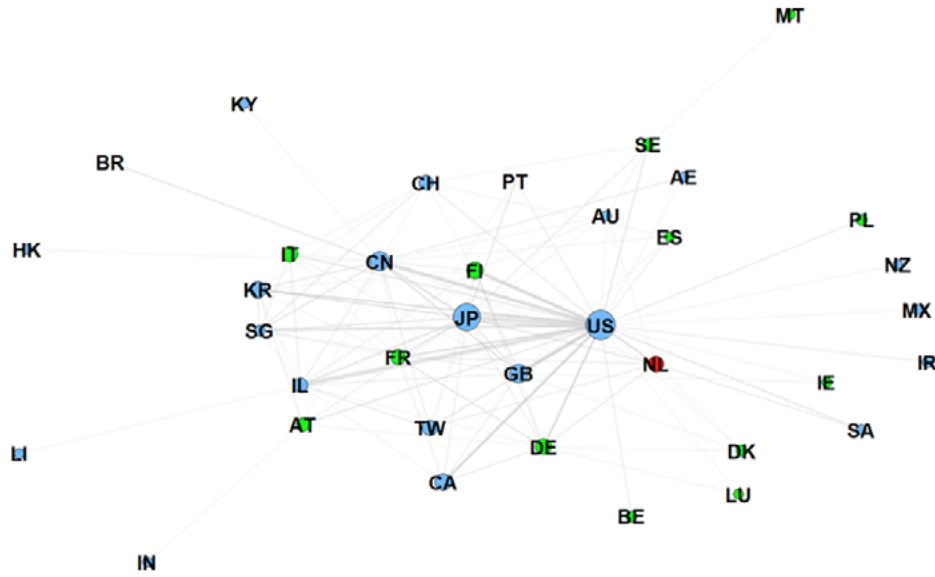


Figure 84: Citation network in optical systems & integrated photonics (Source: TNO Vector).

*Technology position the Netherlands: Quantum technologies*

- The United States, Japan and China are dominant global players in this technological domain.
- The Netherlands is located close to the core cluster of leading countries and relies heavily on EU partners.

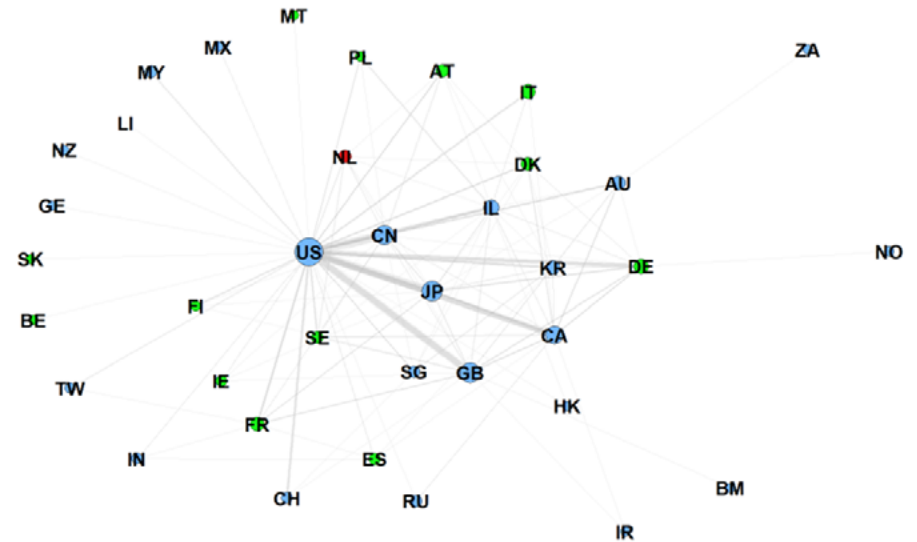


Figure 85: Citation network in quantum technologies (Source: TNO Vector).

*Technology position the Netherlands: Process technologies*

- The United States is a dominant player in this technological domain, followed by South Korea, China, Canada, and Japan.
- The Netherlands ranks among the top 10 most cited countries in this technological field, but relies heavily on knowledge from outside the EU.

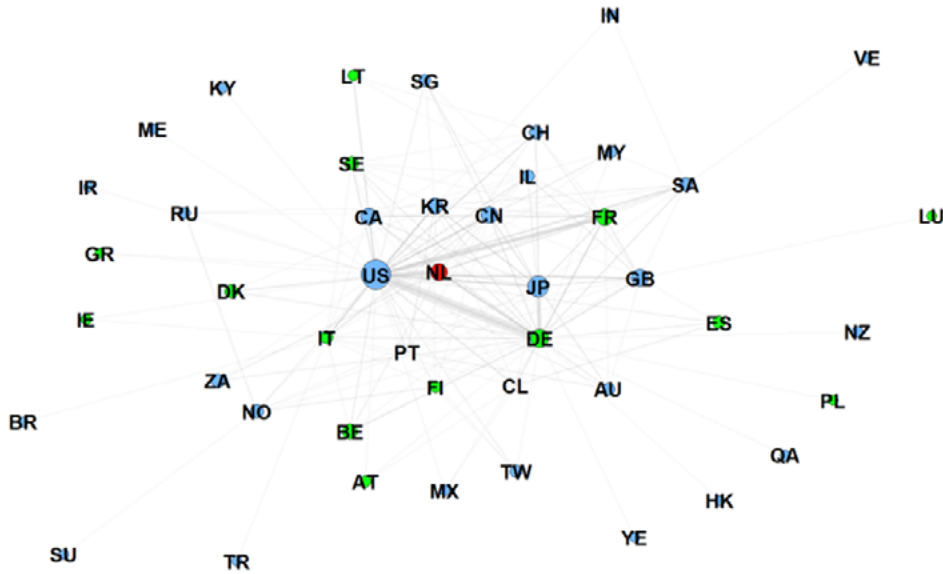


Figure 86: Citation network in process technologies (Source: TNO Vector).

*Technology position the Netherlands: Biomolecular & cell technologies*

- The United States appears to be a particularly dominant player in this technological domain. The United Kingdom also plays an important role.
- The Netherlands is located further away from the core cluster of leading countries.

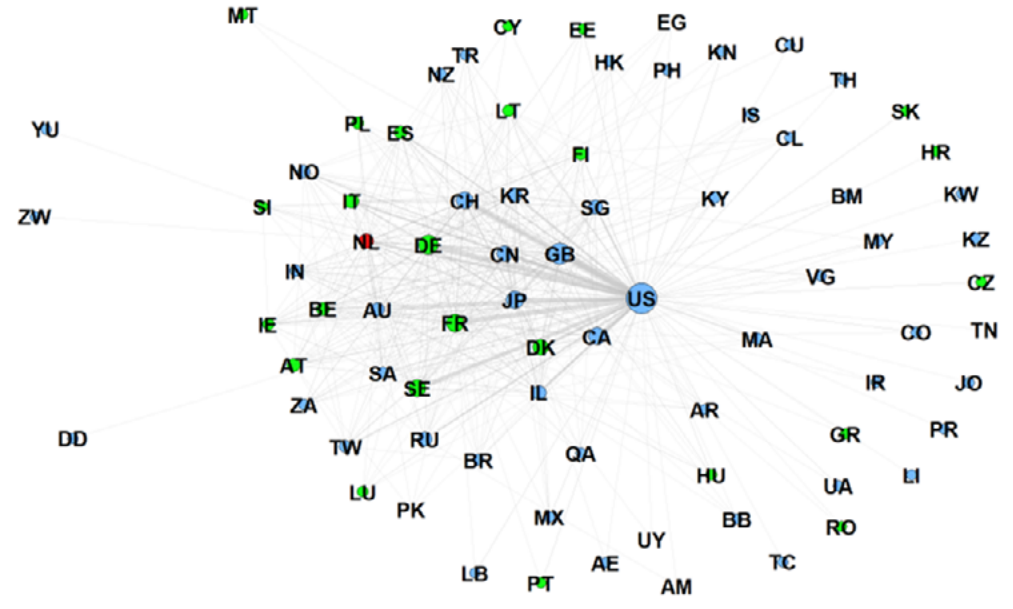


Figure 87: Citation network in biomolecular & cell technologies (Source: TNO Vector).

*Technology position the Netherlands: Imaging technologies*

- The United States is the largest player in this technological field, followed by Japan.
- Philips holds a leading position in terms of the number of patent applications filed.
- The Netherlands enjoys relatively limited international recognition and is dependent on foreign sources of knowledge (outside the EU, OECD, NATO).

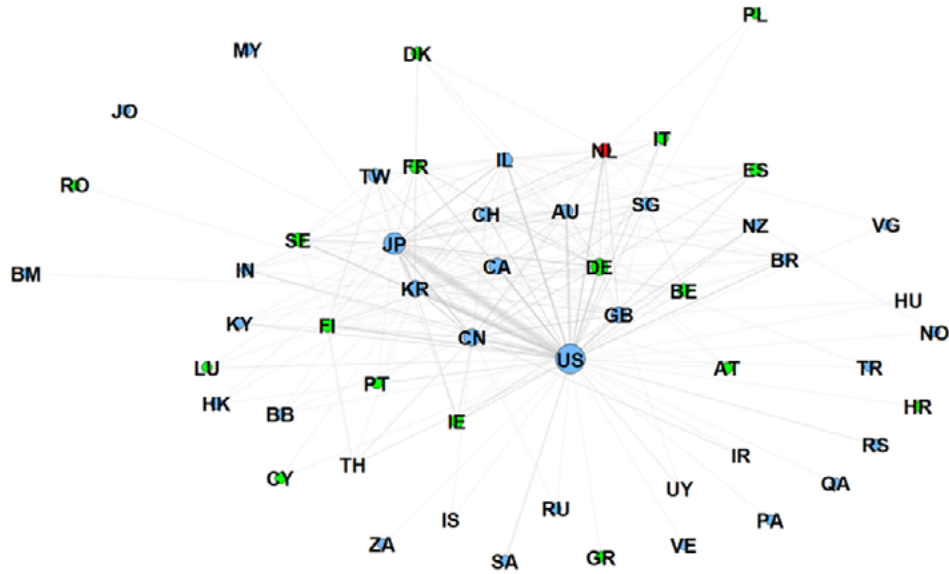


Figure 88: Citation network in imaging technologies (Source: TNO Vector).

*Technology position the Netherlands: (Opto-)mechatronics*

- The United States, China, and Japan appear to be important players in this technological domain.
- The Netherlands is located close to the core cluster of leading countries, building primarily on knowledge from OECD and NATO countries.

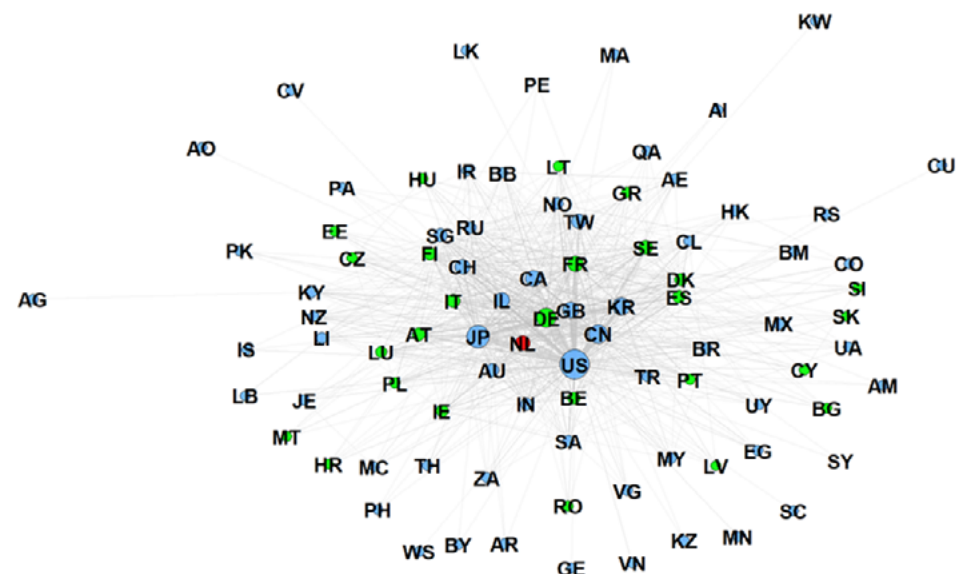


Figure 89: Citation network in (opto-)mechatronics (Source: TNO Vector).



*Technology position the Netherlands: semiconductor technologies*

- Japan, Taiwan, South Korea, and the United States are dominant global players in this technological domain.
- The Netherlands is located close to the core cluster of leading countries.

*Technology position the Netherlands: Cybersecurity technologies*

- The United States is the largest player in this technological field, followed by Canada, South Korea, and Taiwan.
- The Netherlands is located close to the core cluster of leading countries and ranks among the top 10 in terms of technology position in this technological domain

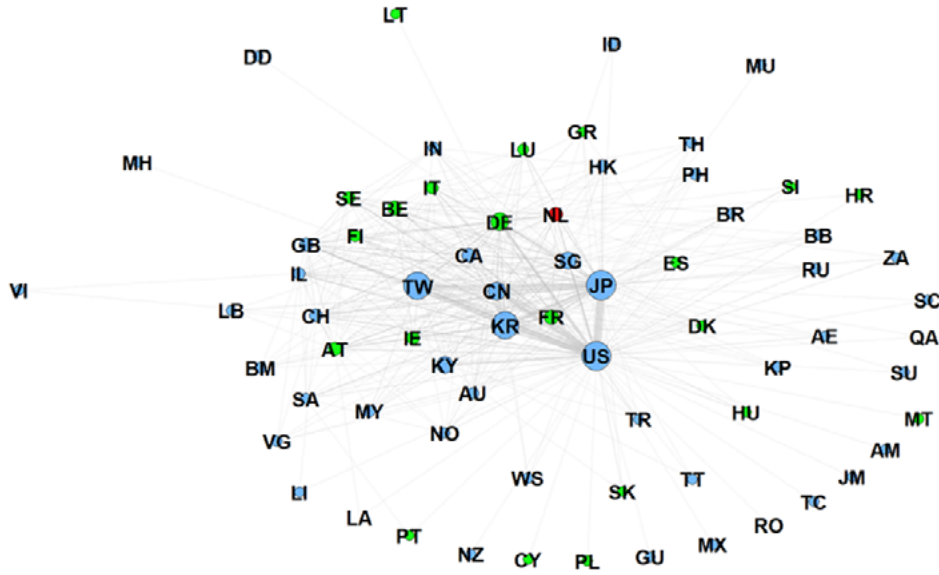


Figure 92: Citation network in semiconductor technologies (Source: TNO Vector).

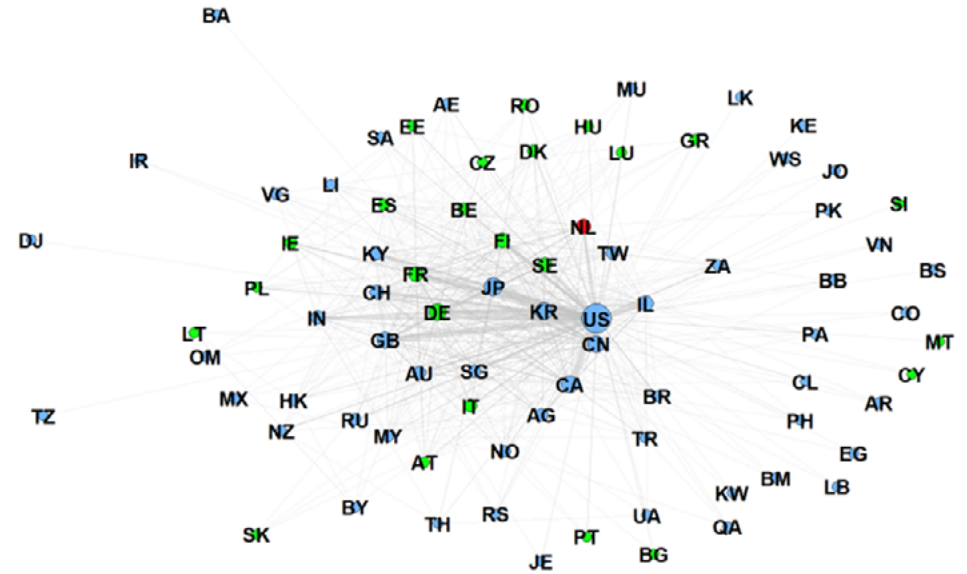


Figure 93: Citation network in cybersecurity technologies (Source: TNO Vector).

**Appendix 7.2.2 – Technology position trend development benchmark**

On the following pages, the development of the Dutch contribution to the global value of NTS patents is compared against a group of benchmark countries (US, China, Japan, South Korea, France, Germany, Sweden, Belgium, and Denmark):

- China and the United States hold a dominant global position regarding the innovation and market value of NTS patents.
- The growth of major global players, such as China, the US, Japan, and South Korea, is significantly stronger than that of European countries. As a result, the difference in patent impact will only increase over time.
- Within Europe, the Netherlands has a technological starting position somewhat comparable to that of Sweden, for example. However, compared to France and particularly Germany, the Netherlands will increasingly lag behind in terms of technological position, as these countries show a faster increase in patent impact. Consequently, the difference will only widen over time.

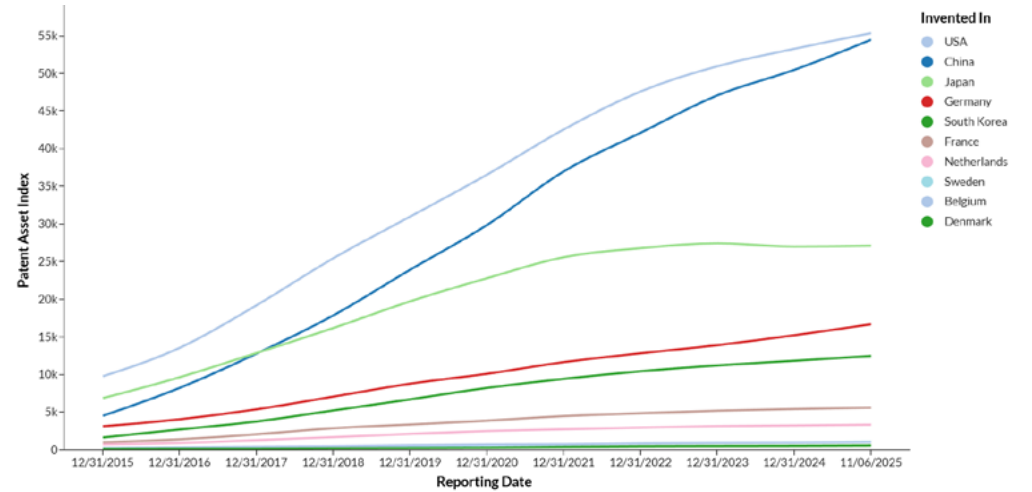


Figure 94: PAI Optical systems and integrated photonics over time for worldwide benchmark countries (Source: TNO Vector).

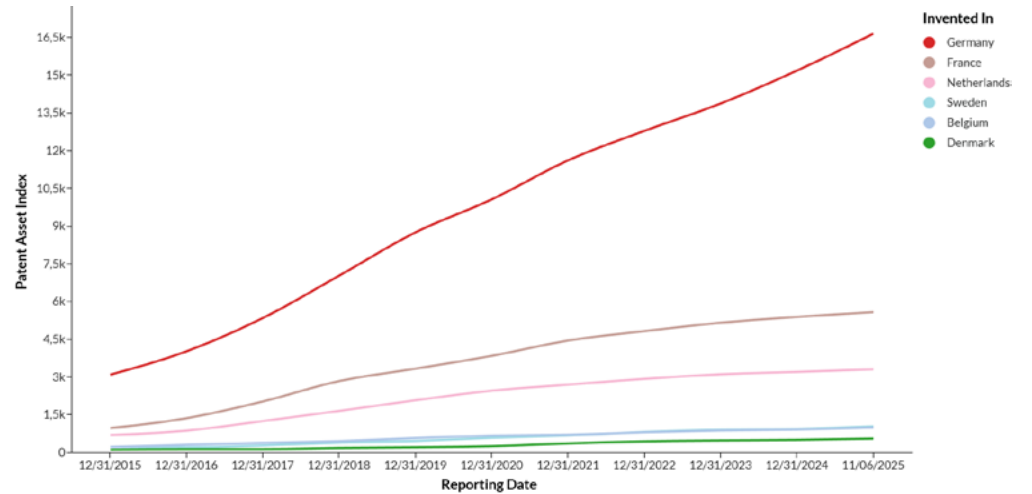


Figure 95: PAI Optical systems and integrated photonics over time for European benchmark countries (Source: TNO Vector).

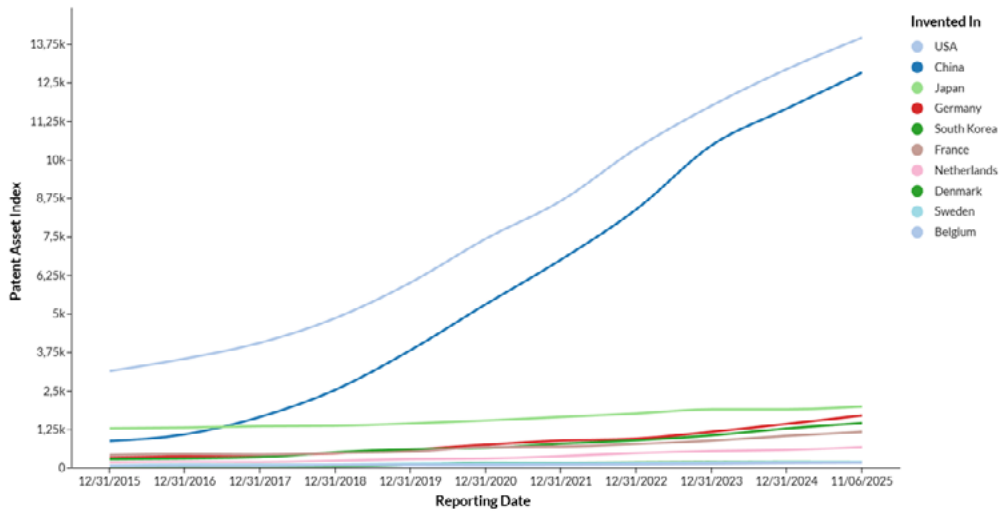


Figure 96: PAI quantum technologies over time for worldwide benchmark countries (Source: TNO Vector).

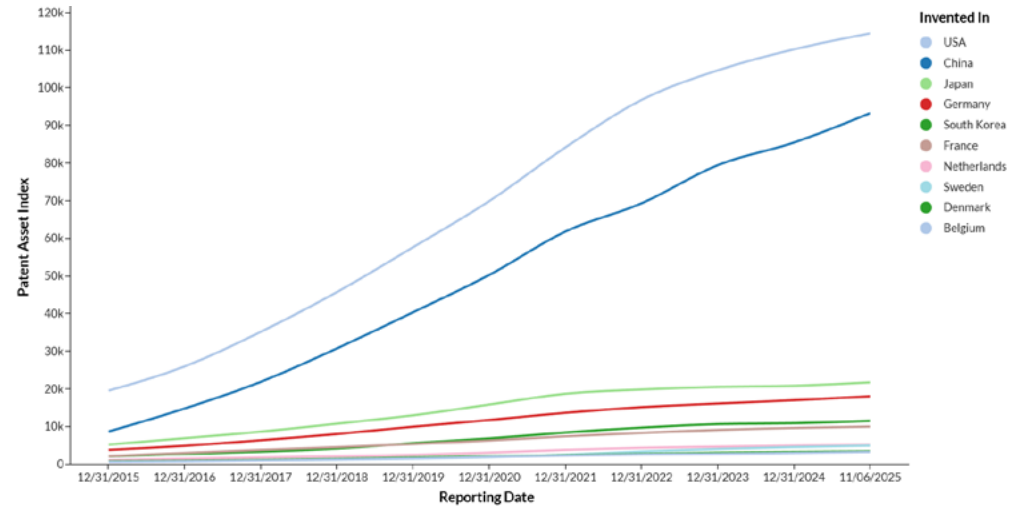


Figure 98: PAI Process technologies over time for worldwide benchmark countries (Source: TNO Vector).

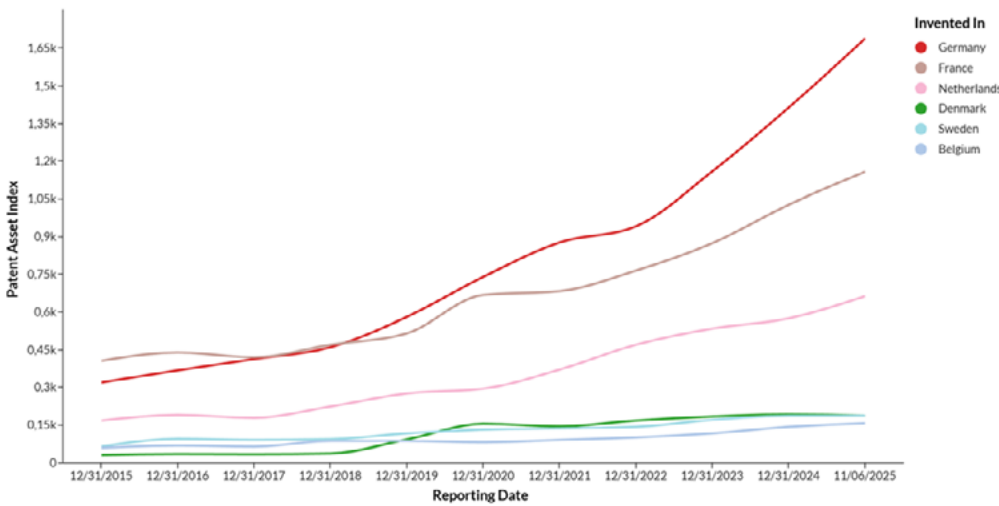


Figure 97: PAI Quantum technologies over time for European benchmark countries (Source: TNO Vector).

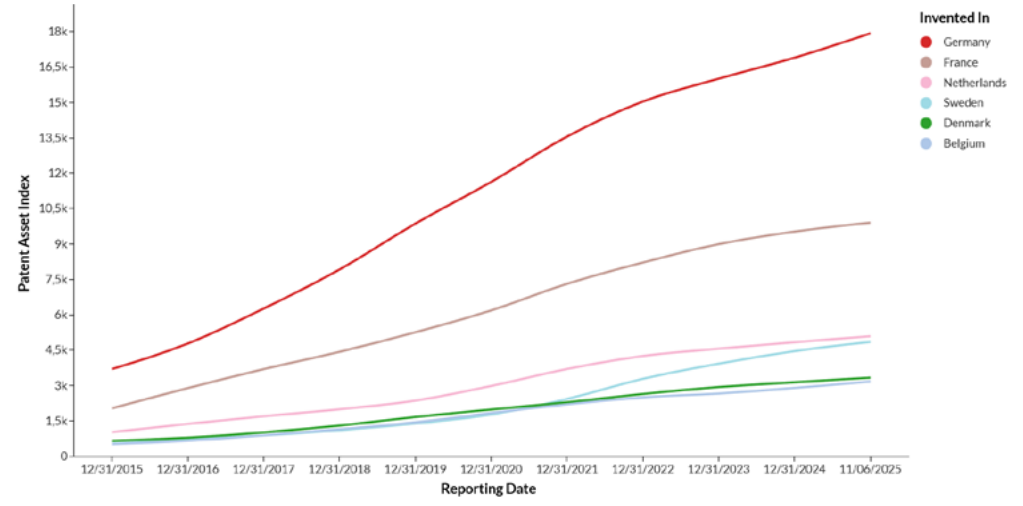


Figure 99: PAI Process technologies over time for European benchmark countries (Source: TNO Vector).

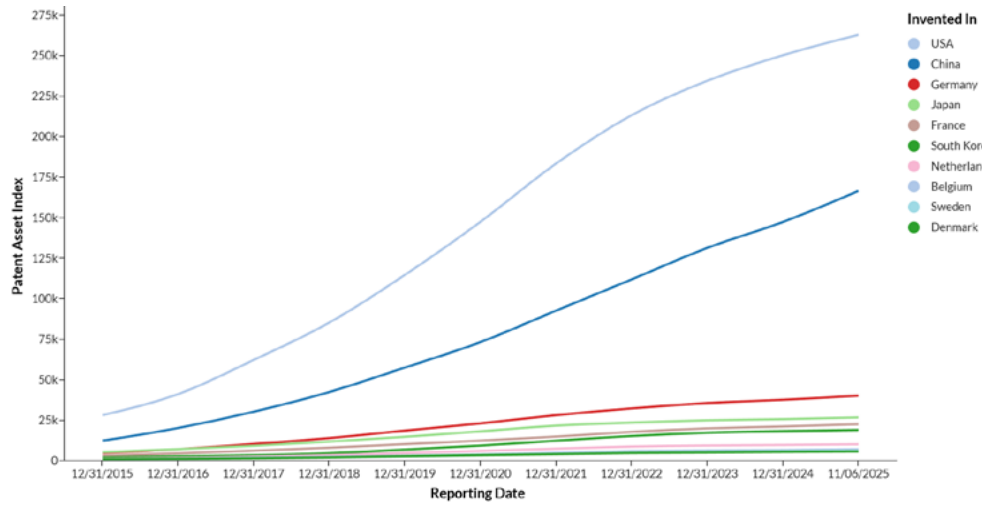


Figure 100: PAI Biomolecular and cell technologies over time for worldwide benchmark countries (Source: TNO Vector).

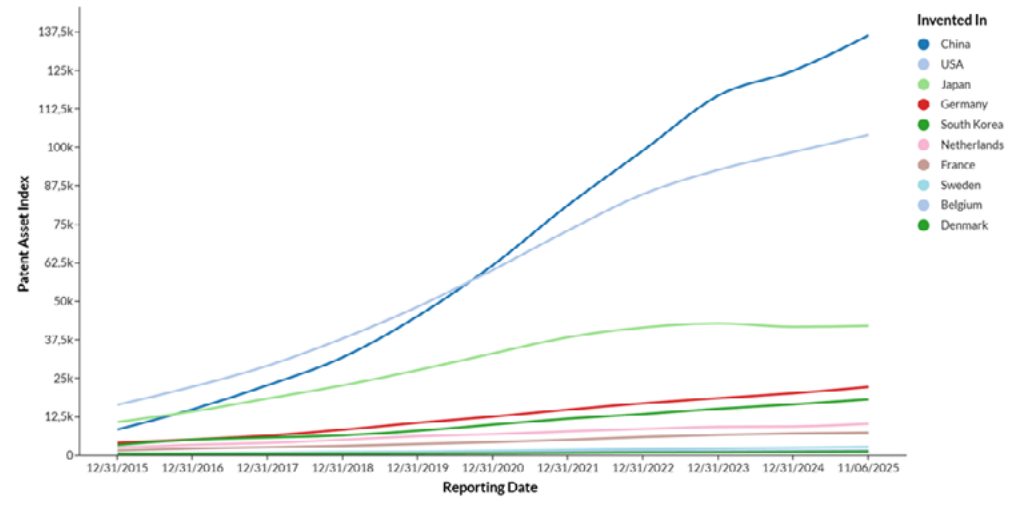


Figure 102: PAI Imaging technologies over time for worldwide benchmark countries (Source: TNO Vector).

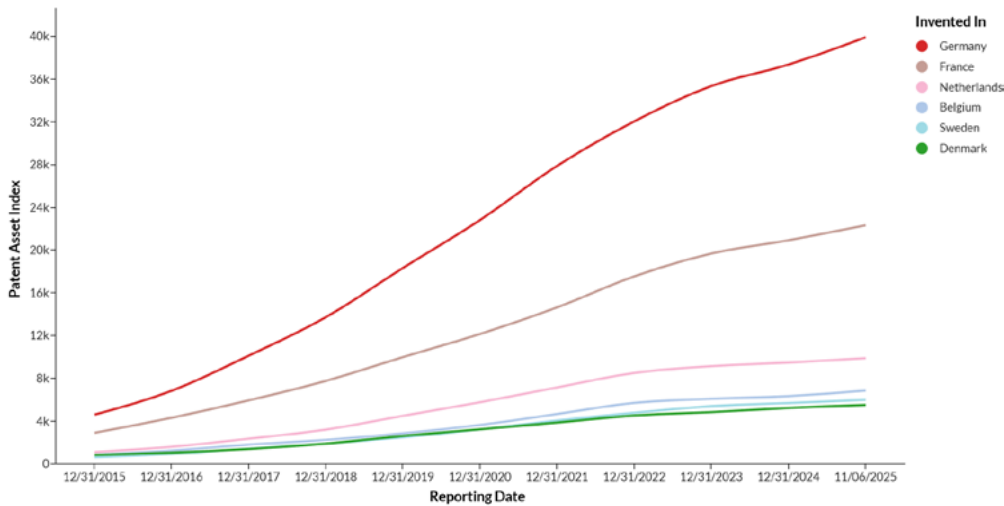


Figure 101: PAI Biomolecular and cell technologies over time for European benchmark countries (Source: TNO Vector).

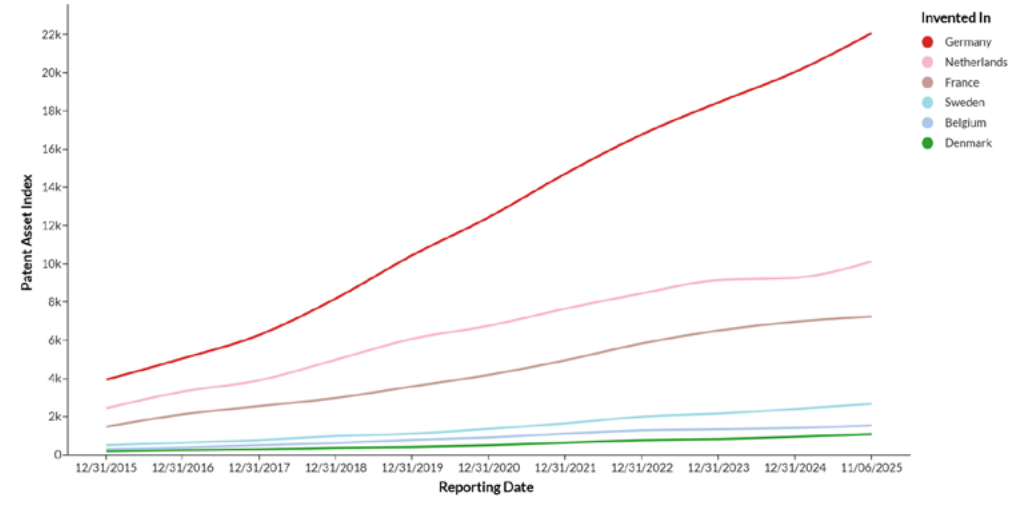


Figure 103: PAI Imaging technologies over time for European benchmark countries (Source: TNO Vector).

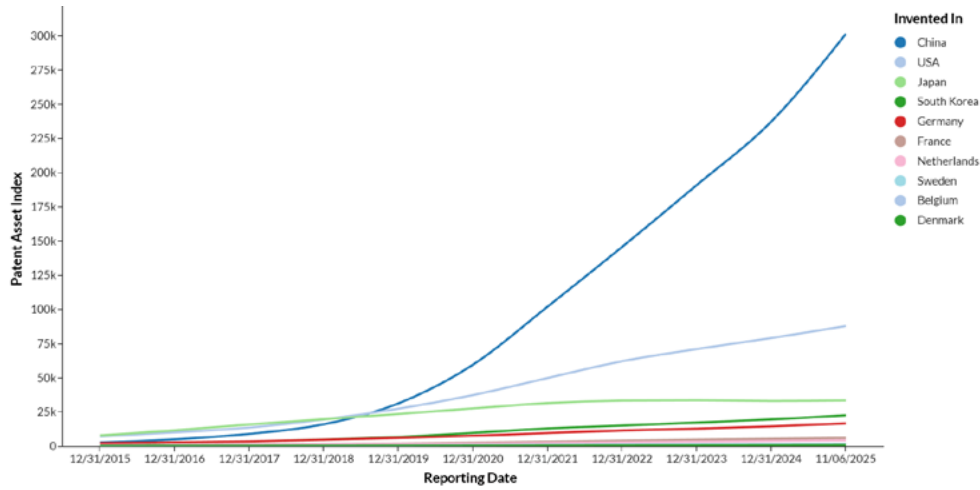


Figure 104: PAI (Opto-) mechatronics over time for worldwide benchmark countries (Source: TNO Vector).

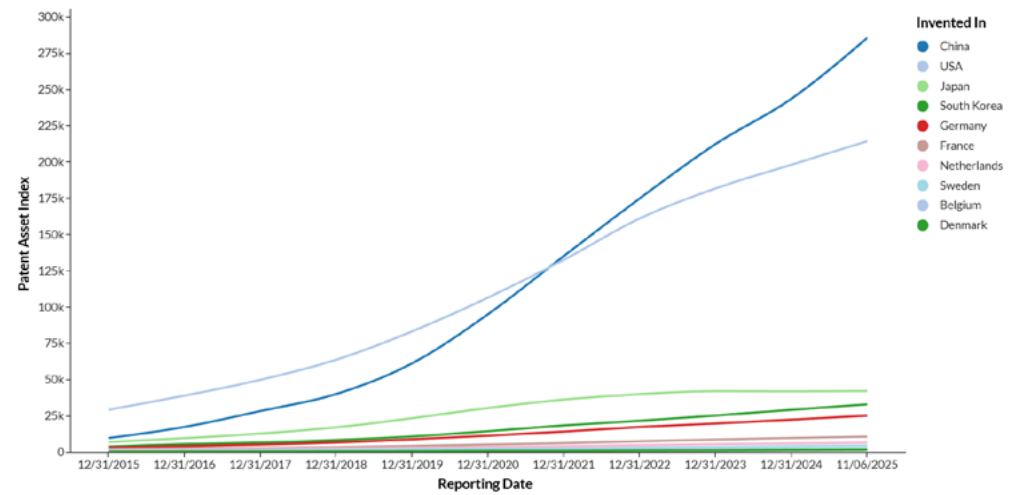


Figure 106: PAI AI and data science over time for worldwide benchmark countries (Source: TNO Vector).

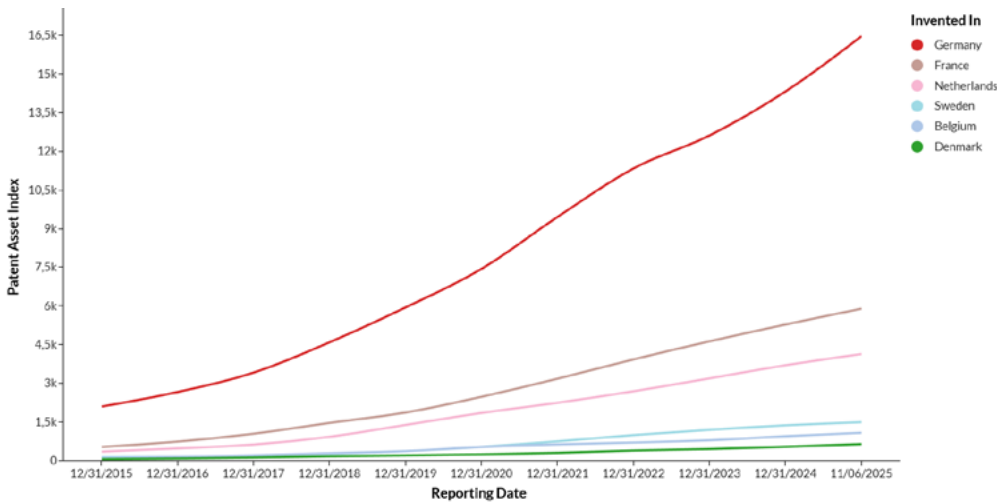


Figure 105: PAI (Opto-) mechatronics over time for European benchmark countries (Source: TNO Vector).

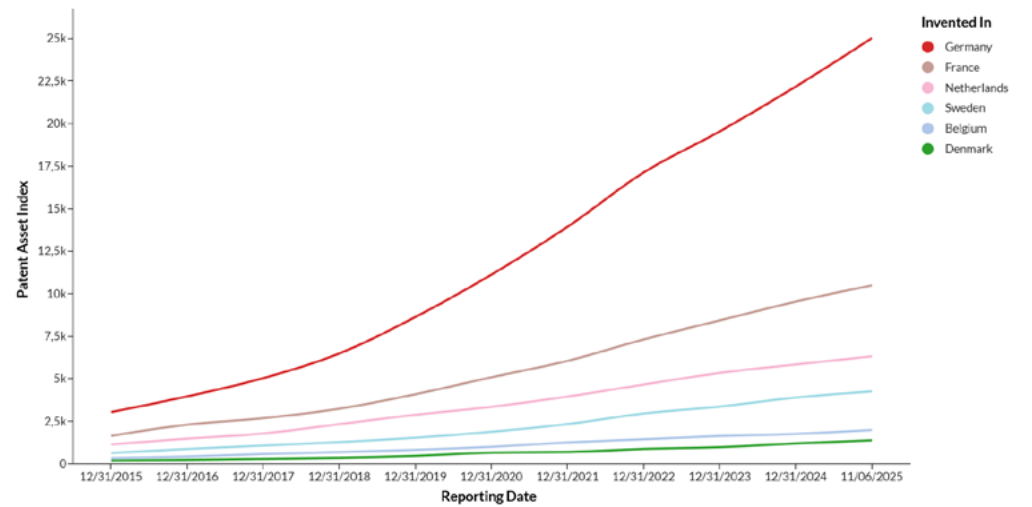


Figure 107: PAI AI and data science over time for European benchmark countries (Source: TNO Vector).

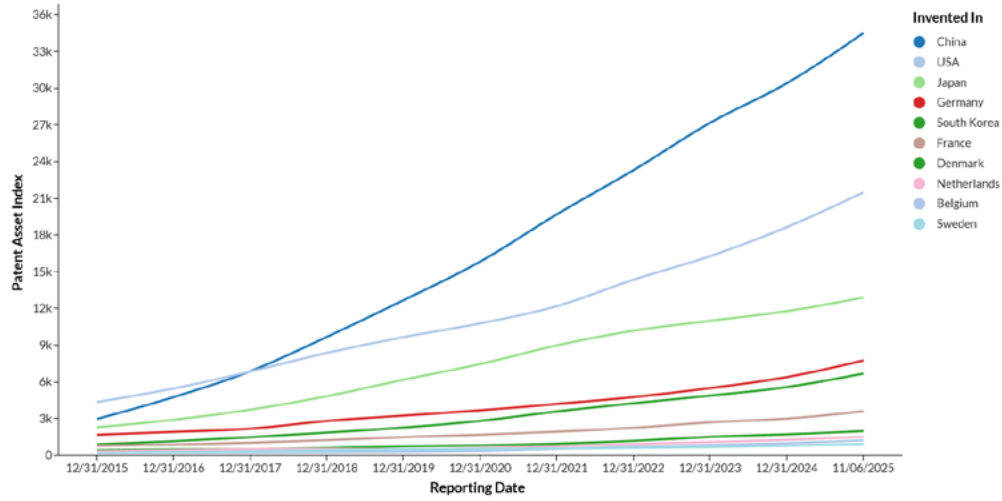


Figure 108: PAI energy materials over time for worldwide benchmark countries (Source: TNO Vector).

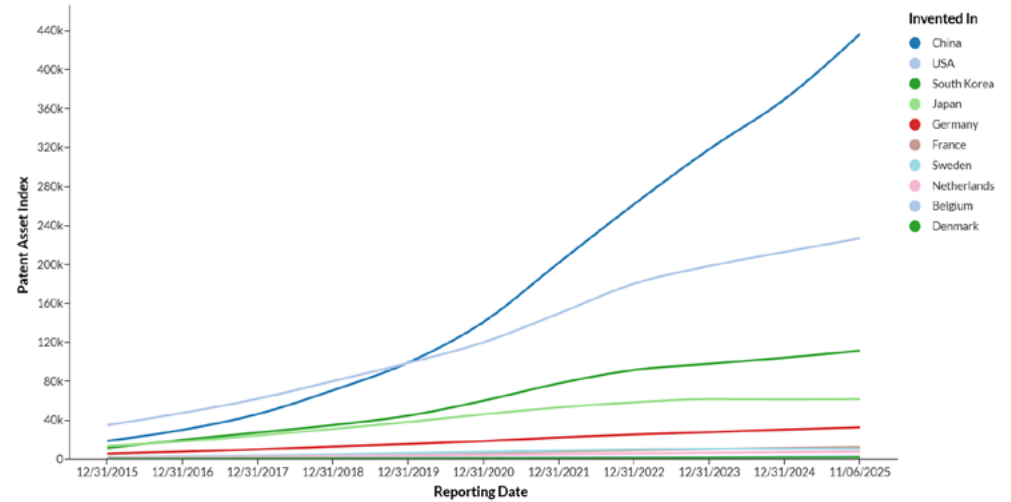


Figure 110: PAI semiconductor technologies over time for worldwide benchmark countries (Source: TNO Vector).

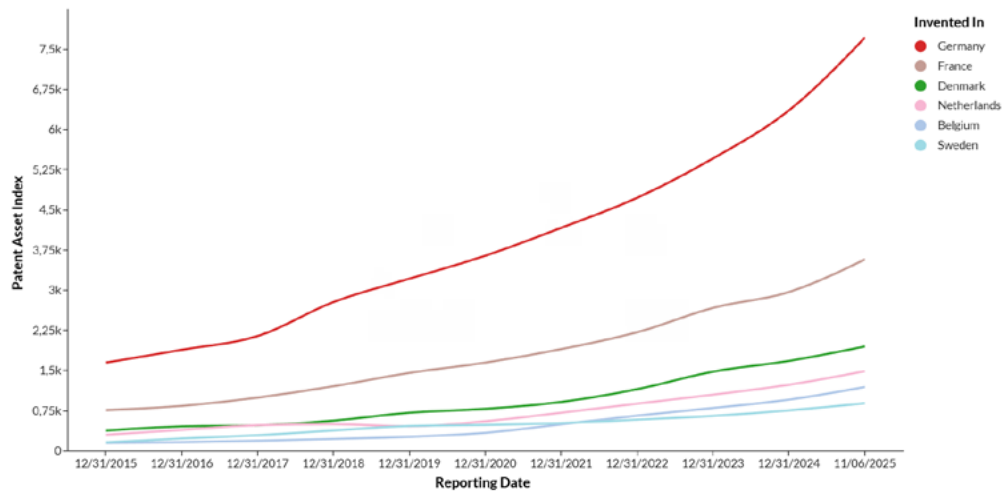


Figure 109: PAI energy materials over time for European benchmark countries (Source: TNO Vector).

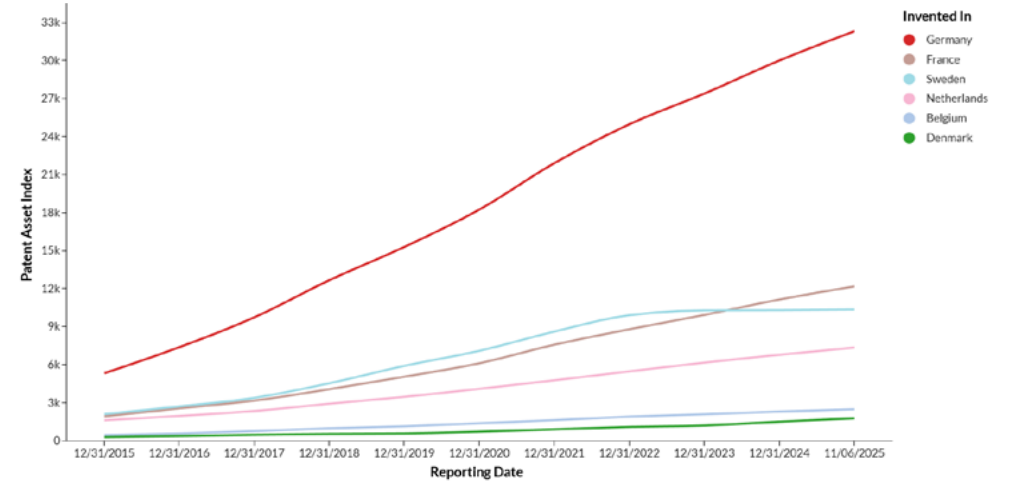


Figure 111: PAI semiconductor technologies over time for European benchmark countries (Source: TNO Vector).

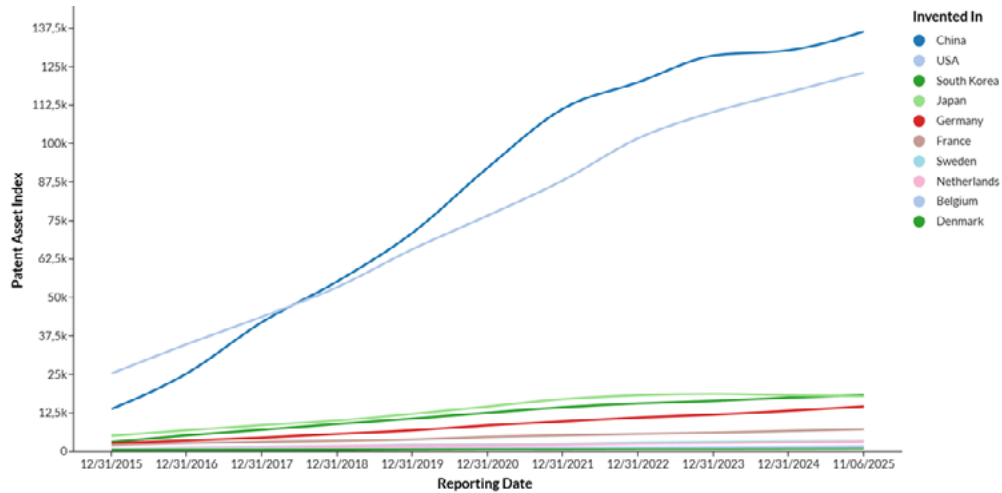


Figure 112: PAI cybersecurity technologies over time for worldwide benchmark countries (Source: TNO Vector).

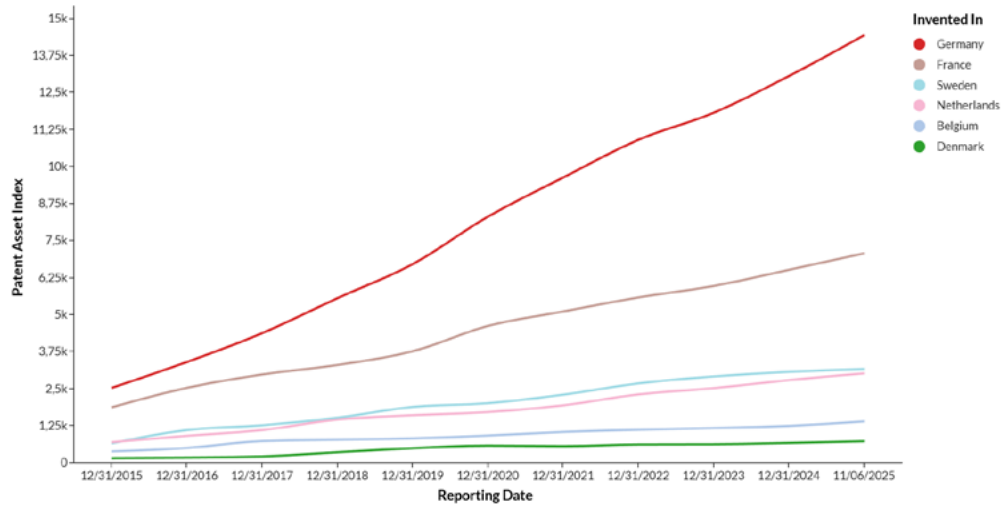


Figure 113: PAI cybersecurity technologies over time for European benchmark countries (Source: TNO Vector).

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12 december 2025



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