Whitepaper

Digitalization of the manufacturing sector in the Netherlands

Smart Industry impact: looking back and forward

TNO innovation for life

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1 Introduction

This report focuses on the digitalization of the Dutch manufacturing sector. The driving forces behind this development are the national technology strategies: AI & data, optomechatronics and mechatronics, optical systems and imaging technology.

Such innovation drives the competitive position of the Netherlands. *"The ambition for the Netherlands is to have the most flexible and best digitally connected production network in Europe, with which the manufacturing companies involved also realize substantial energy and material savings"*.
To achieve this, technology developments are required and take place in the field of IoT, Robotics, Drones, AGV, and AI for smart manufacturing. In addition, it is also necessary to stimulate the development of smart products and services, data ecosystems and return/reuse of products, and to prevent the loss of employees by focusing on lifelong learning and digital skills development.[1]

In recent years, field labs have become an important innovation instrument for the digitalization of the manufacturing sector to stimulate innovation and upscaling and subsequently the competitiveness of the Netherlands and Dutch regions. These field labs, also known as 'joint innovation centres' or public-private partnerships (PPPs), are often physical locations where research and applications are brought together. TNO has a track record in setting up such field labs as well as in monitoring their impact on the digitalization of the manufacturing industry.

1.1 The aim of this study

However, the digitalization of the manufacturing sector doesn't only take place via field labs but also in other ways (e.g. by companies not involved in field labs, via international cooperation's, with the help of HBO's and Universities etc.). The status of the digitalization of the manufacturing sector is often measured via field labs (e.g., via the Monitoring of Field labs[2]) and based on various digital maturity scans (e.g. in the regions and as part of (EU) projects) and based on studies executed by organisations such as ING. However, there is no complete picture of the current status of the digitalization of manufacturing sector in the Netherlands. One of the reasons of this incomplete picture is that the accumulated results of all the digital maturity scans are not available. A reason why field labs are often the instruments applied in the measurements of the status of the digitalization of the manufacturing sector relates to a limited access to contact information of companies and other initiatives active on the digitalization of the manufacturing sector. This is partly caused by the GDPR. It also relates to the difficulty to measure the digitalization of manufacturing based on secondary datasets. This stems from the fact that digitalization of the manufacturing sector is integrated in the manufacturing sector as a whole. Similar issues are present for the Data Economy. For the Data Economy assumptions are made about the percentage of it as part of another industries, however, there is no established method to measure such a digital transformation.

Also, the Dialogic report[3] about the evaluation of Smart Industry was not able to measure all activities related to the digitalization of manufacturing sector in the Netherlands.

The lack of completeness of the studies about the digitalization of manufacturing is difficult to solve given the aforementioned reasons. But the various studies together complement to a clear overview and relevant insights.

Research questions

With our study we want to add to these insights, by answering the following research questions:

- What are the most important developments for the digitalization of the manufacturing in the Netherlands? (see Chapter 2).
- What is the current status of the digitalization of the manufacturing in the Netherlands? (see Chapter 3 and Chapter 4).
- How can we accelerate the uptake of the digitalization of the manufacturing sector in the Netherlands, especially for the late adopters? (see Chapter 5).

Target audience

We answer these questions to give the stakeholders (e.g., associations, regional development organisations, companies, knowledge institutes, policy makers) involved in the manufacturing sector a better overview on the digital maturity level of their sector.

1 Based on expert interviews
2 Monitoring Fieldlabs
3 Evaluatie Smart Industry Dialogic

Research methods

Our study was based on the following methods:

1. Desk research,
2. Interviews with some experts,
3. Analysis of secondary data, that provides insights about Gross Value Added, R&D expenditure and productivity,
4. A survey method among SMEs active in the digitalization of manufacturing.

1.2 Reading guide

In Chapter 2 we describe the technology trends of the digitization in manufacturing to provide insights on what digitalization of manufacturing is thereby outlining the main answers to the first research question. In Chapter 3 the state of digitalization in manufacturing in the Netherlands is discussed and it will be compared with other countries. This provides answers to the second research question. Chapter 4 describes the strengths and weaknesses for SMEs active in the digitalization of manufacturing, since they are the majority of the sector. In Chapter 5 we provide a summarizing conclusion and measures to stimulate the strengths and mitigate the weaknesses that SMEs have to deal with (third research question).

2 Technology trends

Over the years the manufacturing sector moved from Industry 1.0 towards Industry 4.0 (Smart Industry) in which we currently are and we are moving towards Industry 5.0 (see Figure 1).

Each of these industry stages has its own technology trends. We will not discuss them all, but we focus on Industry 4.0 and 5.0 and their underlying technology trends.

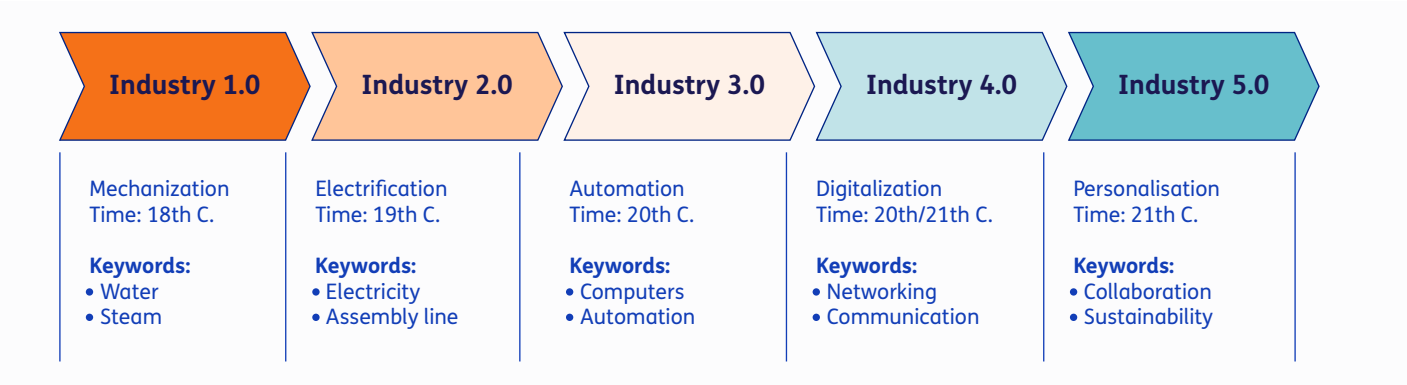

Figure 1 Overview of the Industry trends[4]

2.1 Industry 4.0 and its trends

Currently, we are in the fourth industrial revolution/Smart Industry – digitization of manufacturing – where we see information and communication change. Production systems that already have computer technology are expanded by a network connection and have a digital twin on the Internet for instance. Moreover, the networking of all systems leads to the creation of smart factories. Industry 4.0 has brought us IoT, cloud computing, additive manufacturing, robotics, augmented reality, smart factories, data analytics, and artificial intelligence technologies to automate the factory processes further. We have seen the birth of virtual reality, artificial intelligence, and machine learning startups in this period. However, Industry 4.0 doesn't only apply to the inside of the factory it also turns supply chains in to supply networks enabled by digitalization and the digital connections between companies.

The digitalization of the manufacturing sector is largely embraced by decision makers such as the European Commission, the Ministry of Economic Affairs and the regional development organisations, but also by the Chamber of Commerce, FME, Metaalunie, Knowledge institutes etc. In the Netherlands the initiative started in 2014 under the name Smart Industry.

2.2 Beyond Industry 4.0

The next industrial revolution, Industry 5.0, will bring in personalization on top of the technologies covered in Industry 4.0, and it will be a collaboration between humans and machines. It will employ and synchronize technological advancement with human thinking skills to provide a personalized experience. Concentration is expected to be on robotics, 3D printing, virtual reality, autonomous vehicles, artificial intelligence, wearables, additive manufacturing, nanotechnology, and energy storage. In addition, companies will contribute to Industry 5.0 by enabling automating the manufacturing process better and collecting real-time data. Lastly, Industry 5.0 companies will focus on and bring value to sustainability, clean energy, upcycled materials and decarbonization.

Various experts indicated that the Dutch and European manufacturing industry is not yet halfway through Industry 4.0.[5] It is estimated that the majority of companies are at the end of phase two (called Connectivity) of the six maturity stages for the digitalization of the manufacturing sector as developed by Acatech (see Figure 2).[6]

4 From Industry 1.0 towards Industry 5.0
5 Based on expert interviews.
6 ING-Research-Digitalisering-van-industriele-productieketens

These six maturity stages are[7]:

1. **Computerization**, which is the starting point for digitization and refers to the targeted use of information technologies. In most companies, the computerization stage is largely in a highly advanced state and is used for the efficient design of repetitive activities, as it enables cost-effective production with low error rates and generates the necessary precision, which is indispensable for the production of many modern products.
2. **Connectivity,** the targeted or isolated use of IT is replaced by networked components, whereby IT systems are interconnected and represent a projection of the corporate core business processes. A complete integration between IT (information technologies) and OT (operative technologies) levels has not yet taken place; however, interfaces to business IT are provided by parts of implemented OT.
3. **Digital visibility,** which is based on the previous paths and established with the help of sensors, which enable recording of processes from start to finish with a high amount of captured data. Processes states are no longer limited to individual areas, such as in a production cell, but can be extended to a production system or the entire company in real time in order to create a digital model, also known as the "digital shadow". This digital shadow, which is to be understood as a basic element for the subsequent maturity levels, helps to show what is happening in the company (real time) and enables data-based decision-making in management.
4. **Transparency,** about the correlations in data stocks is needed for a better causal understanding of processes. The recognition and interpretation of interdependencies through the digital shadow requires the analysis of the collected data in the respective context using engineering knowledge. Process knowledge is more and more required to support more complex decisions, which are based on semantic connections and aggregation of data and its corresponding classification in a certain context. This process is supported fundamentally by new technologies for the analysis of mass data.
5. **Predictive capability,** enables simulation of different future scenarios and identification of those that are most likely. To this end, the digital shadow is projected into future-based scenarios and evaluated according to probability of occurrence. This enables companies to anticipate upcoming events, make decisions in time and take adequate reaction measures. Although measures usually still have to be initiated manually, the effects of a disruption can be limited in time due to the time gained through the pre-warning. Reducing such disruptions or planning variance, which represent unexpected events in the business process, enables more robust operation.
6. **Adaptability,** can enable an automatic reaction to expected machine failures or delays in delivery through a modified sequence in production planning. If a company manages to exploit data of the digital shadow in such a way that decisions are made autonomously, with the best positive results in the shortest possible time and the corresponding measures are taken, then stage six of the model has been successfully implemented. It is, however, important to assess carefully the risks of automating approvals. For this a correct cost-benefit ratio must be provided.

7 Acatech Industrie 4.0 Maturity Index – A Multidimensional Maturity Model

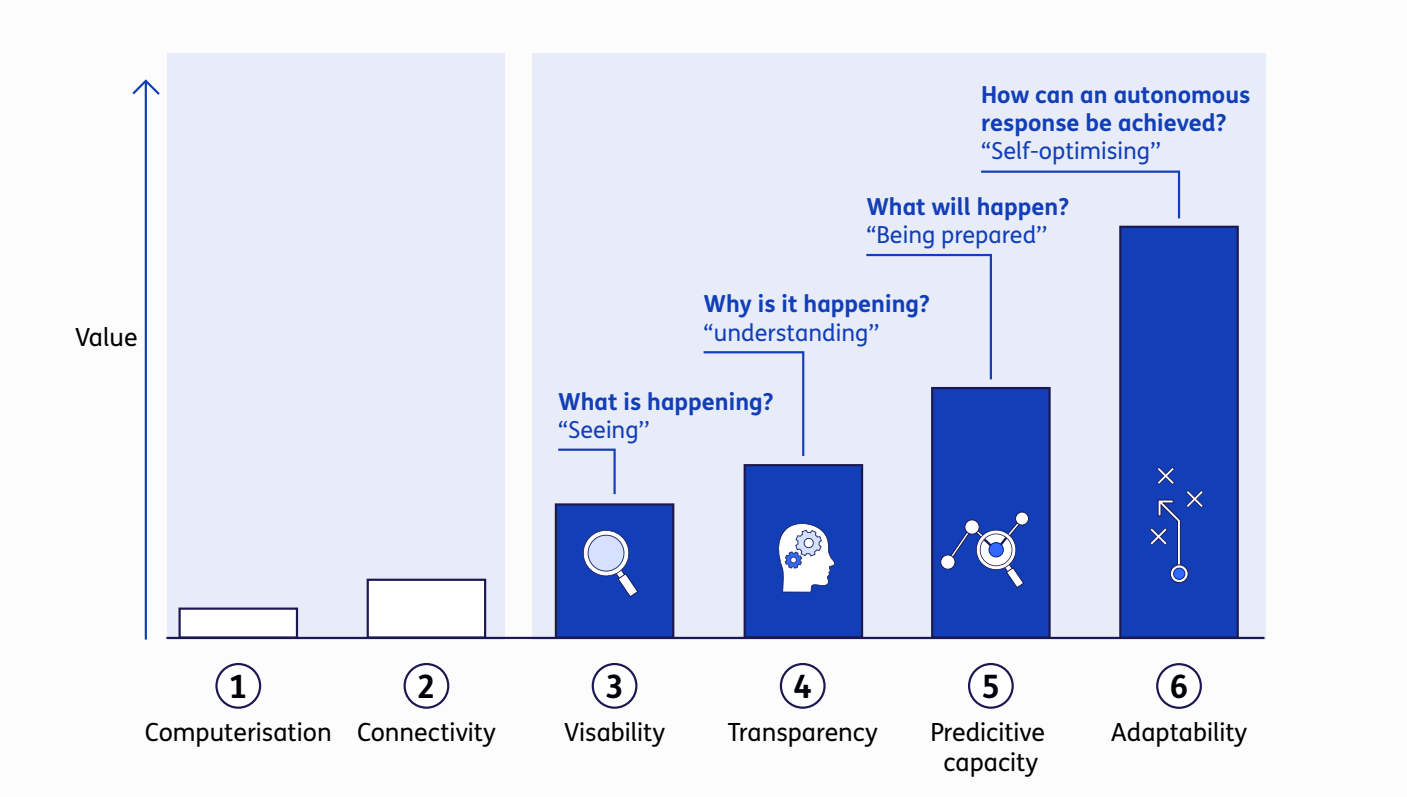

Figure 2 Maturity levels for the digitalization of manufacturing[8]

In the next Chapters we will dive deeper into the current status of the digitalization of the manufacturing sector as a whole and for SMEs in particular to indicate how far the sector is with these trends.

8 Acatech Industrie 4.0 Maturity Index – A Multidimensional Maturity Model

3 The country perspective

This chapter provides an overview of the state of play of the sector working on the digitalization of manufacturing in the Netherlands (all companies including SMEs). The overview is based on secondary data. However, not everyone applies the same definition or same scope to the sector working on the digitalization of manufacturing, meaning that not everyone might include the same SBI/NACE codes to select the subsectors. We selected the 19 underlying subsectors as presented in Table 3.1.

Within this chapter the comparisons are made between the sector working on the digitalization of manufacturing, the manufacturing sector and the whole economy of the Netherlands. The manufacturing sector includes all the subsectors and manufacturing of tobacco products (SBI/NACE 12), printing and reproduction of recorded media (SBI/NACE 18), manufacturing of coke and refined petroleum products (SBI/NACE 19), manufacturing of chemicals and chemical products (SBI/NACE 20), manufacturing of basic pharmaceutical products and pharmaceutical preparations (SBI/NACE 21).

SBI/ NACE	Short description	Smart Industry	Manufacturing
10	Manufacture of food products	√	√
11	Manufacture of beverages	√	√
12	Manufacture of tobacco products		√
13	Manufacture of textiles	√	√
14	Manufacture of wearing apparel	√	√
15	Manufacture of leather and related products	√	√
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	√	√
17	Manufacture of paper and paper products	√	√
18	Printing and reproduction of recorded media		√
19	Manufacture of coke and refined petroleum products		√
20	Manufacture of chemicals and chemical products		√
21	Manufacturing of basic pharmaceutical products and pharmaceutical preparations		√
22	Manufacture of rubber and plastic products	√	√
23	Manufacture of other non-metallic mineral products	√	√
24	Manufacture of basic metals	√	√
25	Manufacture of fabricated metal products, except machinery and equipment	√	√
26	Manufacture of computer, electronic and optical products	√	√
27	Manufacture of electrical equipment	√	√
28	Manufacture of machinery and equipment n.e.c.	√	√
29	Manufacture of motor vehicles, trailers and semi-trailers	√	√
30	Manufacture of other transport equipment	√	√
31	Manufacture of furniture	√	√
32	Other manufacturing	√	√
33	Repair and installation of machinery and equipment	√	√

Table 3.1 Measuring the manufacturing sector active on digitalization based on the following SBI codes

Source: Statistics Netherlands.

3.1 Digitalization of the manufacturing sector

In the Netherlands there were 72.125 enterprises active in 2022 in the sector working on the digitalization of manufacturing (called Smart Industry in all Tables and Figure below).[9] Together, these 72.125 enterprises generated 81.102 mln Euro in gross value added in 2022 (see Figure 3).

The gross value added (GVA) is the difference between production and the intermediate use of energy, materials and services. This accounted for 9,4%, almost 10% of the total economy in 2022 (Figure 4). It has however reduced slightly since 2020, when it was 9,7%.

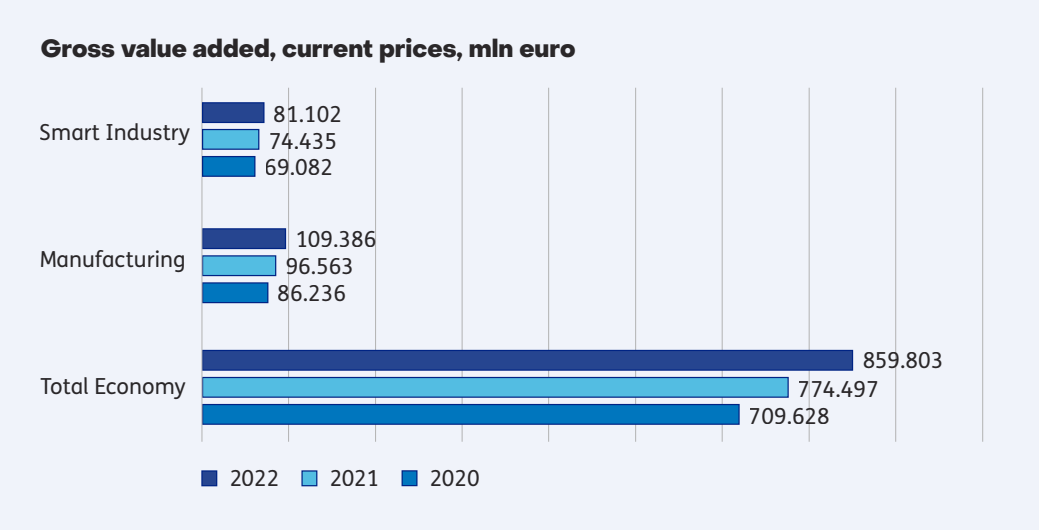

Figure 3 Gross value added of the sector working on the digitalization of manufacturing (see Smart Industry) reached 81.102 mln Euro in 2022

Source: Statistics Netherlands, National Accounts 2022. Data for 2022 are provisional

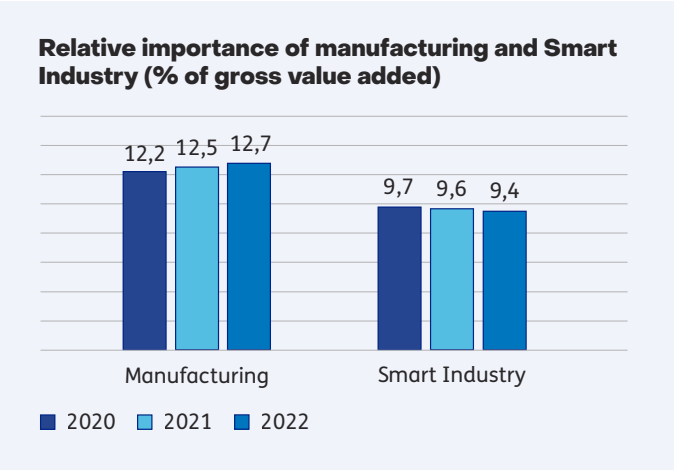

Figure 4 The share of the sector active on the digitalization of manufacturing (see Smart Industry) in total economy slightly reduced since 2020 reaching the level of 9,4% in 2022

Source: Statistics Netherlands, National Accounts 2022. Data for 2022 are provisional

9 At the moment report was prepared the latest available data for 2022 was data at the end of the second quarter of 2022.

Since 2015, gross added value of the sector working on the digitalization of manufacturing have been growing similarly to the manufacturing sector (Table 3.2). In 2020 it experienced a drop in GVA growth but it recovered remarkably in 2021 and 2022, reaching the growth rates of 10,4% and 5,9% respectively. The developments in the gross value added followed the developments within the whole industry sector, however the growth rates have been surpassing the ones of the manufacturing sector.

GVA growth basis prices (in %)	2016-2022	2020	2021	2022
Total Economy	**2,4**	**-4,1**	**6,6**	**4,8**
Manufacturing	3,5	-2,3	10,4	3,8
Smart Industry	3,9	-2,3	10,4	5,9

Table 3.2 – Gross value added of the digitalization of manufacturing (see Smart Industry) has been growing on average at the rate of 3,9% since 2016

Source: Statistics Netherlands, National Accounts 2022. Data for 2022 are provisional

The sector working on the digitalization of manufacturing employed 669.000 FTEs in 2022 (see Table 3.3 and Table 3.4 for the growth percentages). The 669.000 FTE amounted to 8,2% of the total economy or 89,3% of the manufacturing sector as a whole. This level has been fluctuating slightly in the past years ranging between 633.000 in 2015-2016 and 673.000 in 2019.

Among the sub-sectors of the sector working on the digitalization of manufacturing, manufacturing of machinery and equipment is the largest both in terms of employment and terms of gross value added since 2015. In addition, the GVA has been increasing since 2015 with an average annual growth rate of 10,7% (see Table 3.5). Manufacturing of food products is the second largest sub-sector in terms of value added and employment, but it has been growing at a much more modest yearly rate of 1,7%.

Absolute value	2015	2016	2017	2018	2019	2020	2021*	2022*
Total Economy	**7015**	**7159**	**7340**	**7561**	**7751**	**7670**	**7859**	**8145**
Manufacturing	698	703	710	723	739	738	737	750
Smart Industry	633	633	640	655	673	669	662	669

Table 3.3 Number of full time employees (in thousands) has slightly increased since 2015

Source: Statistics Netherlands, National Accounts 20222. Data for 2022 are provisional

Growth rate	2015	2016	2017	2018	2019	2020	2021*	2022*
Total Economy	**1,2%**	**0,9%**	**2,0%**	**3,2%**	**3,2%**	**-0,1%**	**-0,9%**	**1,6%**
Manufacturing	1,3%	2,1%	2,5%	3,0%	2,5%	-1,0%	2,5%	3,6%
Smart Industry	0,6%	0,7%	1,0%	1,8%	2,2%	-0,1%	-0,1%	1,8%

Table 3.4 Growth rate of the number of full time employees

Source: Statistics Netherlands, National Accounts 20222. Data for 2022 are provisional

	2020	2021	2022[10]	Relative importance	Average growth rate (2016-2022)
Manufacture of food products	12.971	13.211	14.210	17,5%	1,7%
Manufacture of beverages	1.321	1.450	1.543	1,9%	0,4%
Manufacture of textiles, wearing apparel, leather and related products	1.187	1.402	1.226	1,5%	1,2%
Manufacture of wood and of products of wood and cork, except furniture;	1.273	1.419	1.726	2,1%	3,5%
Manufacture of paper and paper products	2.180	1.774	2.044	2,5%	-1,9%
Manufacture of rubber and plastic products	3.207	3.364	3.544	4,4%	3,3%
Manufacture of other non-metallic mineral products	2.347	2.362	2.503	3,1%	4,4%
Manufacture of basic metals	1.749	2.617	3.539	4,4%	2,9%
Manufacture of fabricated metal products, except machinery and equipment	7.489	7.810	8.498	10,5%	2,4%
Manufacture of computer, electronic and optical products	4.102	4.331	5.099	6,3%	5,6%
Manufacture of electrical equipment	3.449	3.536	3.620	4,5%	4,3%
Manufacture of machinery and equipment n.e.c.	14.602	17.465	20.472	25,2%	10,7%
Manufacture of motor vehicles, trailers and semi-trailers	2.684	2.882	2.630	3,2%	3,7%
Manufacture of other transport equipment	1.551	1.463	1.268	1,6%	3,3%
Manufacture of furniture	1.476	1.527	1.616	2,0%	-2,0%
Other manufacturing	3.853	3.937	3.614	4,5%	-1,7%
Repair and installation of machinery and equipment	3.641	3.885	3.950	4,9%	1,3%
Total Smart Industry	**69.082**	**74.435**	**81.102**	**100%**	**3,9%**

Table 3.5 Relative importance of the sub-sectors of the sector active on the digitalization of manufacturing

Source: Statistics Netherlands, National Accounts 2022. Data for 2022 are provisional

While these three sectors experienced no slowing down in the production, the Covid-19 pandemic had an apparent effect on multiple sub-sectors. It had the biggest effect on the sub-sectors of Manufacturing of beverages, Manufacturing of motor vehicles, trailers and semi-trailers, and Manufacturing of furniture, where GVA in prices of 2015 had dropped by 18,6%, 25,2% and 11,9% respectively. All these sectors recovered since then.

Of the 72.125 enterprises active in the digitalization of manufacturing in 2022[10], the majority of these enterprises are small and medium sized enterprises (97%, see Figure 5). Specifically 69.935 or 97% of the enterprises employ up to 50 persons. The subsectors of manufacturing of paper and paper products and manufacturing of rubber and plastic products employ the lowest number of SME's in relative terms. In Chapter 3 we pay extra attention to these SMEs.

10 At the moment report was prepared the latest available data for 2022 was data at the end of second quarter of 2022.

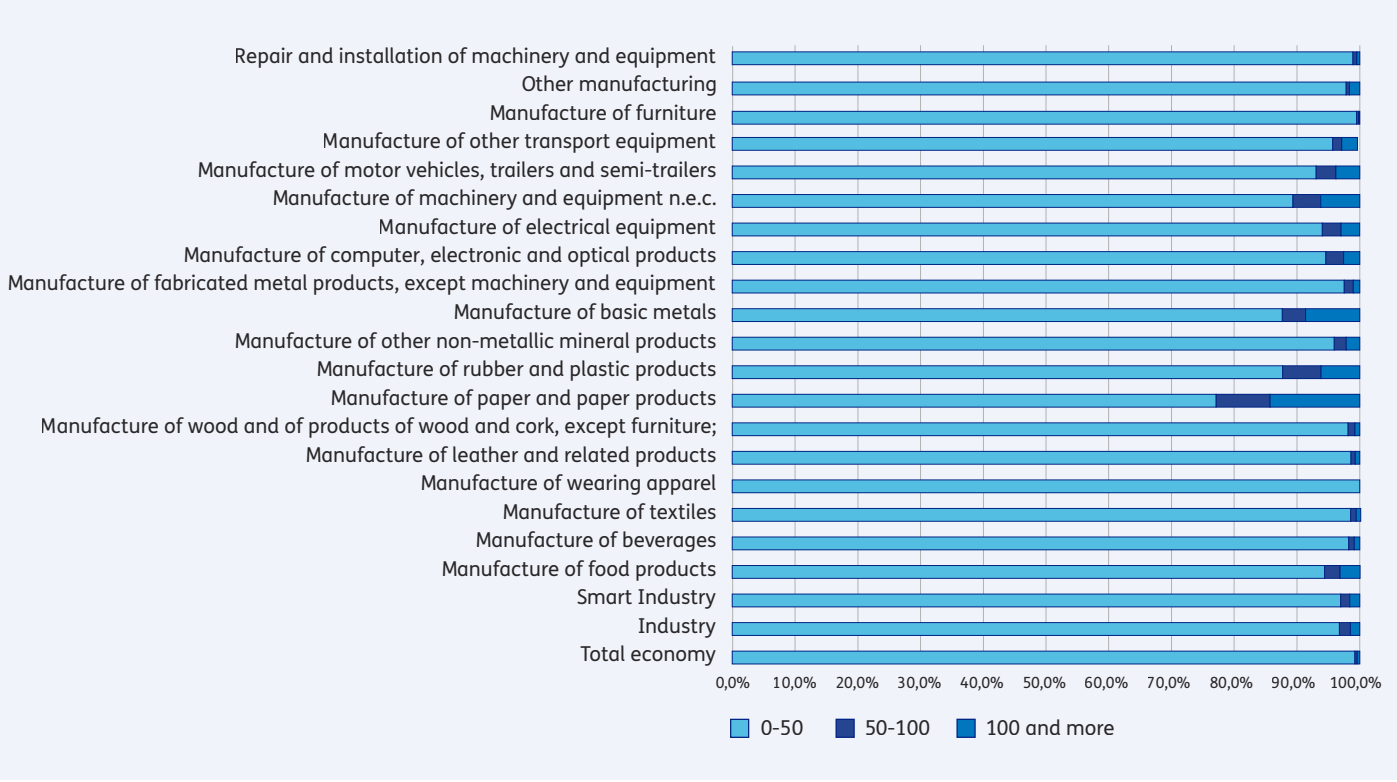

Figure 5 Most of the enterprises within the sector active on the digitalization of manufacturing were SME's in 2022 similarly to the manufacturing sector and total economy as a whole

Source: Statistics Netherlands, National Accounts, Q2 2022

R&D expenditures

In 2021 the Netherlands spent around 19.752 mln Euro on research and development[11], comprising of expenditures by enterprises, institutions and higher education institutions. This is an increase of over 1 mln Euro compared to 2020 and over 1,5 mln Euro compared to 2019. Since 2013 the research and development expenditures have been increasing. The majority of these expenditures were conducted by enterprises: 13.048 mln Euro or 66% of the total R&D expenditures.

Within the manufacturing sector, businesses spent 6.505 million Euro in 2021. Of this R&D expenditures, 81,6% were spent by the enterprises within the Smart Industry: 5.310 mln Euro. Since 2013 these expenditures have been growing by 6,9% on average[12] within sector working on the digitalization of manufacturing. This is higher than the average growth rate of the business R&D expenditures of the whole manufacturing industry (4,1%) as well as that of the whole economy (4,3%).

Among the different sub-sectors within the sector active on the digitalization of manufacturing, machinery and manufacturing of computer, electronic and optical products invested the most in R&D in 2021: 2.664 million Euro and 949 million Euro respectively. The following subsectors invested somewhere average: 182 mln Euro by manufacturing of fabricated metal products, 215 mln Euro by Manufacturing of motor vehicles, trailers and semi-trailers, 347 mln Euro by Manufacturing of food products, and 556 mln Euro by manufacturing of electrical equipment. Other subsectors invested between 5 and 86 mln Euro in 2021.

While the R&D expenditures in absolute terms have been increasing over the past decade, the share of it in GDP or R&D intensity in the Netherlands has been increasing only slightly, reaching the level of approximately 2.3% in 2021. The level of R&D intensity within the sector active on the digitalization of manufacturing was on average much higher: 7,1%. It was also much higher than the level of R&D intensity for the whole manufacturing sector (see Figure 6). Within the sector active

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12 This is the average growth rate of business expenditures between 2013 and 2021.

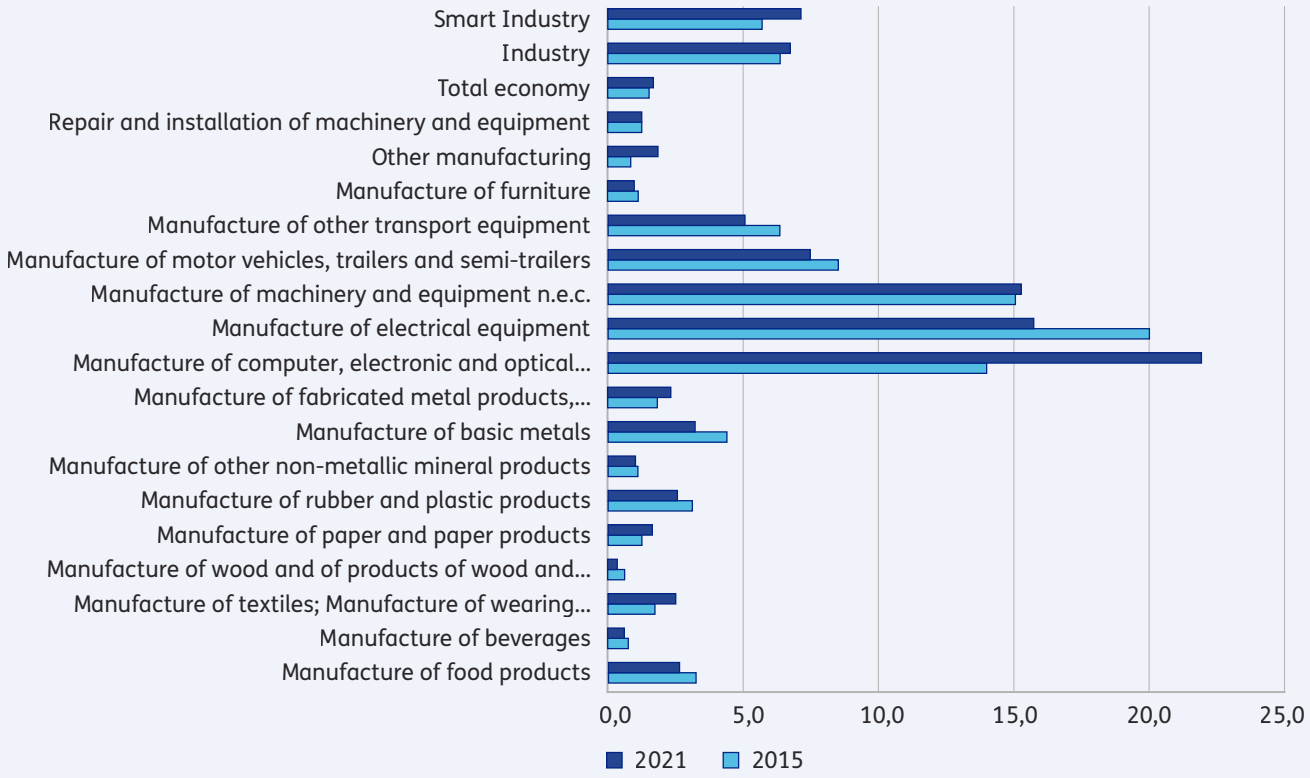

Figure 6 On average within the sector working on the digitalization of manufacturing the R&D intensity has increased since 2015

Source: Statistics Netherlands, National Accounts

on the digitalization of manufacturing, the level of R&D intensity is quite different. In 2021 R&D intensity was the highest in the sub-sector of manufacturing of computer, electronic and optical products (21,9%). It is followed by manufacturing of electrical equipment (15,7%) and manufacturing of machinery and equipment (not elsewhere classified) (15,3%). For a few sub-sectors the R&D intensity was however lower than that of the whole economy in the Netherlands.

Export

The total export of goods and services in the Netherlands was 898 billion Euros in 2022. This was higher than the level of it in 2021 (732 billion Euros). Overall the export of goods and services has been growing since 2015, with a drop in value in 2020 due to COVID-19 pandemic. The growth rate was on average 3,2% per year since 2015.

The exports of goods and services comprises of two categories: domestically produced export or domestic export and re-export.[13] Re-exports is the exports of goods previously imported to the Netherlands and then exported in a completely or nearly unprocessed condition, from which there are little or no earnings to the Dutch economy. The level of re-exports accounted for 44,8% of the total exports (327 billion Euros) in 2022 as shown in Table 3.6. The level of re-exports accounted for 44,8% of the total exports (327 billion Euros) in 2022 as shown in Table 3.6. Domestically produced export accounted for 69% of the total exports or 504.914 million Euro in 2021.

The sector working on the digitalization of manufacturing is responsible for 162.937 million Euros of all domestically produced exports in 2022. It has been increasing by 1,9% on average since 2015, with the exception of 2020 where it

13 Other positions within the total export constitute usually less than 10% and are not used further in the report.

Export value by category	Export value 2021, mln euro	Export value 2022*, mln euro	Share of total exports 2022
Total domestic produced exports ('made in the Netherlands')	412.802	504.914	56,2%
Exports by NL Manufacturing industries	215.217	264.883	29,5%
Exports by NL Smart Industry	**139.710**	**162.937**	**18,1%**
Growth rate of exports by NL Smart Industry	1,4%	3,4%	
Re-exports	258.086	327.679	36,5%
Product-related taxes less subsidies	2.804	3.960	0,4%
Trade and transport margins	61.117	67.715	7,5%
Cif/fob-corrections	-2.600	-5.607	-0,6%
Total Exports	**732.209**	**898.661**	**100%**

Table 3.6 The sector active on the digitalization of manufacturing (Smart Industry) domestically produced export has been rising over the past years reaching the level of 162 billion Euros in 2022

Source: Statistics Netherlands, National Accounts (2022 provisional)

dropped by 6% compared to that of 2019. It's share in total exports however decreased from 22% in 2015 to 18,1% in 2022. Among the sub-sectors of the sector working on the digitalization of manufacturing, manufacturing of basic metals and manufacturing of motor vehicles, trailers and semi-trailers are the top exporters in terms of the export intensity, that is measured as a share of the export in the production value. The export intensity reached the levels of 71,3% and 75,8% respectively in 2022. Manufacturing of other non-metallic mineral products, manufacturing of furniture and repair and installation of machinery and equipment are on the other hand the sub-sectors with the lowest export intensity: 21,9%, 22,3% and 21,2% respectively in 2022.

A relative large share of domestic production in the sector active on the digitalization of manufacturing is exported. On average 52,3% of the produced goods and were exported in 2022. The top three exporters within the sector working on the digitalization of manufacturing in 2022 were goods and services produced and applied within computer, electronic and optical products, motor vehicles and basic metals with the export intensity of 75,8%, 75,8% and 71,3% respectively. The following subsectors exported the least as a share in production value: repair and installation of machinery, manufacturing of other non-metallic mineral products, manufacturing of furniture with the export intensity being around 21,5% in 2021.

3.2 The Netherlands vs other countries

When comparing the Dutch sector working on the digitalization of manufacturing with other European countries we see a couple of things. Germany, France and Italy are top three countries in terms of the share of the value added of manufacturing. Together they accounted for 56% of the EU value added in 2020 and 50% of the EU employment. Together with the Netherlands and Finland, these countries add up to 62% of the EU value added and 54% of the EU employment in 2020.

When looking at the sector working on the digitalization of manufacturing, these Member States account for even larger share of the EU employment: 62% in 2020.

The share of the digitalization of manufacturing (see Smart Industry) within the non-financial business economy's value added varies between countries (Figure 7, Table 3.7).

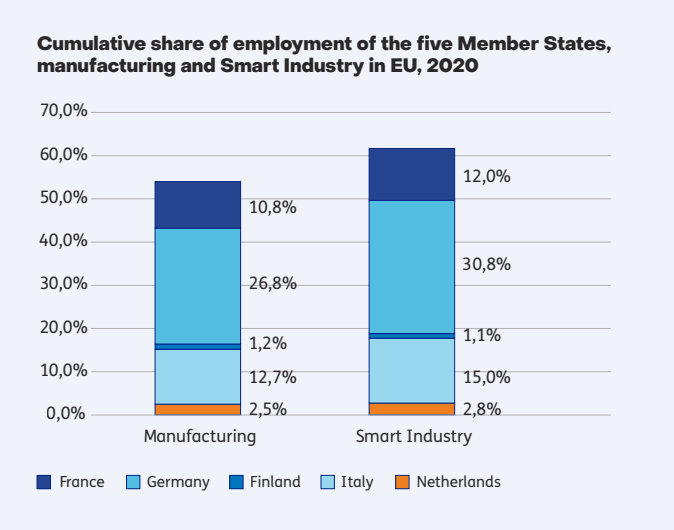

Figure 7 The share of employment of the sector active on the digitalization of manufacturing (Smart Industry) of five Member States accounts for a larger share in EU than that of the EU in 2020

Among these five member states, this share was the lowest in 2020 in the Netherlands: 16,1%. In Germany and Italy it was the highest reaching 28,8% of the non-financial business economy's value added.

In 2020 the highest apparent productivity among the sub-sectors working on the digitalization of manufacturing was recorded in the Netherlands (Table 37). It reached the level of €91.000 per person employed in 2020. It grew in 2021 reaching the level of €105.700 per person employed in 2021 (Figure 8). This was much higher than the level of productivity in Italy, Finland, Germany and France with the average labour productivity of €72.100, €91.500, €79.600 and €81.400 per person employed respectively in 2021. At the same time, it was above the EU average apparent labour productivity in 2019 and 2020 (see Figure 8). The highest levels of productivity were recorded in Ireland, Denmark and Belgium, with the Netherlands ranking fourth. The productivity however has been growing with a decreasing speed over the past 20 years. This is a worldwide trend for the whole manufacturing sector[14].

The sub-sectors active on the digitalization of manufacturing are diverse combining sub-sectors with low and high labour productivity. Manufacturing of furniture showed the lowest level of labour productivity in all five countries in 2021: 49.150 Euro in France, 52.930 Euro in Germany, 54.690 Euro in Italy, 59.840 Euro in Finland and 61.000 Euro in the Netherlands. The highest performing sub-sectors differ between the countries. In Italy and Finland the highest labour productivity was 113.250 Euro and 171.560 Euro respectively in manufacturing of basic metals, while in Germany it was 125.820 Euro in manufacturing of motor vehicles, trailers and semi-tralers. In France it was 140.720 Euro in manufacturing of beverages. While in the Netherlands the highest productivity was reached by manufacturing of computer, electronic and optical products (179.900 Euro).

Key indicators: Smart Industry in 2020	Netherlands	Italy	Finland	Germany	France
Number of enterprises	71.373	342.748	18.749	204.459	198.694
Share of number of enterprises in manufacturing	93,5%	95,0%	94,3%	92,7%	91,4%
Number of persons employed	649.983	3.475.985	250.331	7.155.716	2.788.239
Share of number of persons employed in manufacturing	88,6%	92,8%	73,6%	90,8%	87,7%
Turnover	261.559	757.163	90.667	1.838.707	774.151
Value added	64.576	198.780	21.387	523.179	185.020
Apparent labour productivity (thousand Euro per head) – average within SI	91,0	59,3	68,8	69,3	68,0

Table 3.7 The sector active on the digitalization of manufacturing (Smart Industry) varies greatly among the Member States

Source: Eurostat (sbs_na_ind_r2)

14 ING-Research-Digitalisering-van-industriele-productieketens

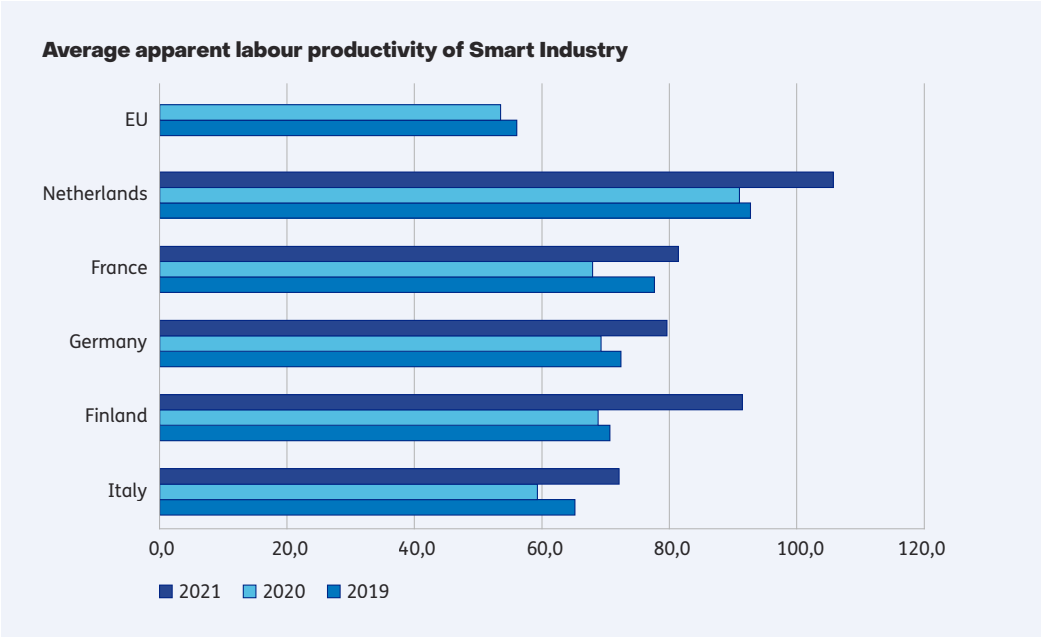

Figure 8 Average apparent labour productivity of the sector active on the digitalization of manufacturing (Smart Industry) (thousands euro)

Source: Eurostat (sbs_na_ind_r2)

In value added terms, Germany was the largest EU Member State in majority active on the digitalization of manufacturing in 2020. While Italy was largest in three: the textiles, wearing apparel, and leather and related products. France was the largest for the manufacturing of other transport equipment.

Compared to the other Member States, the Netherlands specializes in Manufacturing of food products and Manufacturing of machinery and equipment not elsewhere classified. These subsectors active on the digitalization of manufacturing constituted 3,1% and 3,7% of the non-financial business economy in terms of the gross value added in 2020 (see Table 3.8).

	Netherlands	Germany	France	Finland	Italy
Smart Industry	16,1%	28,8%	19,1%	20,5%	28,8%
Manufacture of food products	3,1%	2,3%	3,8%	2,3%	3,3%
Manufacture of beverages	0,3%	0,4%	0,7%	0,4%	0,6%
Manufacture of textiles	0,2%	0,2%	0,2%	0,2%	0,7%
Manufacture of wearing apparel	0,0%	0,1%	0,2%	0,1%	1,1%
Manufacture of leather and related products	0,0%	0,1%		0,1%	0,8%
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0,3%	0,5%	0,3%	1,3%	0,5%
Manufacture of paper and paper products	0,6%	0,7%	0,5%	2,2%	0,8%
Manufacture of rubber and plastic products	0,8%	1,6%	0,9%	0,9%	1,8%
Manufacture of other non-metallic mineral products	0,6%	1,0%	0,9%	1,0%	1,3%
Manufacture of basic metals	0,4%	1,0%	0,4%	1,3%	1,2%
Manufacture of fabricated metal products, except machinery and equipment	1,8%	3,0%	1,9%	2,6%	4,0%
Manufacture of computer, electronic and optical products	1,1%	2,0%	1,3%		0,9%
Manufacture of electrical equipment	0,7%	2,5%	1,0%	1,5%	1,4%
Manufacture of machinery and equipment n.e.c.	3,7%	5,4%	1,5%	4,1%	4,9%
Manufacture of motor vehicles, trailers and semi-trailers	0,6%	5,0%	1,6%	0,6%	1,5%
Manufacture of other transport equipment	0,4%	0,7%	1,9%	0,4%	1,2%
Manufacture of furniture	0,4%	0,4%	0,2%	0,3%	0,8%
Other manufacturing	0,3%	1,1%	0,7%	0,2%	0,9%
Repair and installation of machinery and equipment	0,9%	0,8%	1,1%	1,0%	1,0%

Table 3.8 Relative importance of sector active on the digitalization of manufacturing (Smart Industry) in terms of share of value added in the non-financial business economy, in 2020

Source: Eurostat (sbs_na_ind_r2)

However, although Germany, France and Italy are the top three countries in terms of the share of the value added of manufacturing and although Germany was the largest EU Member State active on the digitalization of manufacturing in 2020, we see some remarkable developments. The industrial digitalization in the Netherlands is slightly more advanced than in Germany and is widely above the EU average.[15]

However, the industry in the Nordic EU countries and in Ireland is clearly stronger digitized than the other countries in the EU.[16] Sweden and Ireland are leading in the EU when it comes to digitalization of manufacturing. In those countries, 60% of the companies are highly or very highly digitized, while in the Netherlands 41% of the industrial enterprises is digitalized and 59% not.[17]

15 ING-Research-Digitalisering-van-industriele-productieketens
16 Ibid
17 Ibid

Between 2018 and 2022, the gap with the international front-runners has decreased somewhat, but increased when comparing with frontrunners in other sectors (see Figure 9.1 and 9.2).[18]

Accelerated digitalization Industry

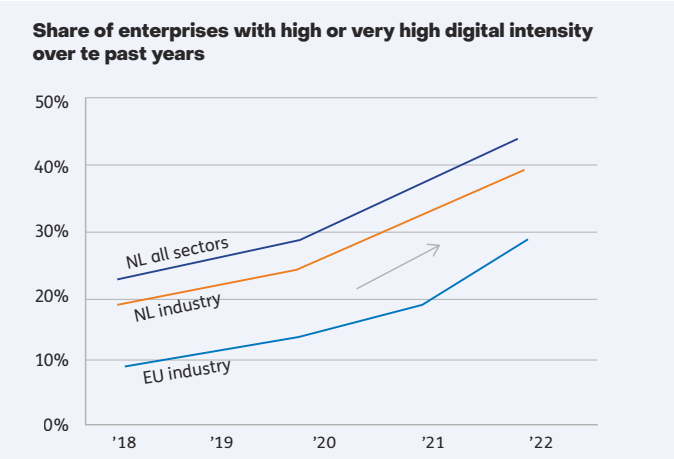

Figure 9.1 Digitalization of all Dutch sectors, the manufacturing sector in the Netherlands and in the EU[19]

but the sector is lagging behind frontrunners

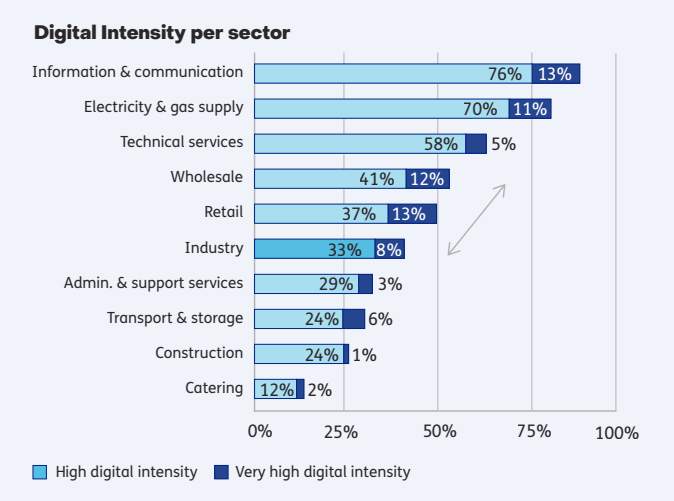

Figure 9.2 Source: ING Research based on Eurostat

Concluding remarks

The Dutch manufacturing sector that is active on digitalization covers a wide range of manufacturing activities. The manufacturing sector active on digitalization is the fastest growing sub-sector within the manufacturing and the whole economy of the Netherlands since 2016. In addition, the R&D intensity of the manufacturing sector active on digitalization is very high. In particular, it was the highest for the manufacturing of computer, electronic and optical products in 2021.

A relatively large share of domestic production in of the sector active on the digitalization of manufacturing is exported. On average 52,3% of the produced goods and services active in this sector were exported in 2022. The top three exporters within this sector in 2022 were goods and services produced by computer, electronic and optical products, motor vehicles and basic metals. Compared to the other Member States, the Netherlands specializes in Manufacturing of food products and Manufacturing of machinery and equipment not elsewhere classified.

The sector active on the digitalization of manufacturing in the Netherlands has a relatively high average productivity compared to the other EU Member States such as: Germany, France, Italy and Finland. The industrial digitalization in the Netherlands is slightly more advanced than in Germany and is widely above the EU average.[20] But smaller countries such as Sweden and Ireland are leading in the EU when it comes to digitalization of manufacturing.[21]

One reason the Nordic countries such as Sweden have been successful in digitisation has been their focus on cultural acceptance and community engagement.[22] Nordregio research found that 20% of digital transformation is about the technology, with the vast majority relying on people and how they manage the transformation.[23] *"The municipalities and regions that are seen to be the front runners on digitalization will tell you to start with the community instead of the technology,".*[24] "Also, they actually invest time and resources into the process of change; *they don't expect change to happen overnight, and they don't expect it to happen by itself."*[25]

18 https://assets.ing.com/m/488f90dcba58baab/original/ING-%ADResearch-Digitalisering-van-industriele-productieketens-april-2023.pdf
19 ING research obv Eurostat
20 ING-Research-Digitalisering-van-industriele-productieketens
21 Ibid
22 The Nordics are doubling down on their digital lead - Tech Monitor
23 Ibid
24 Ibid
25 Ibid

4 Strengths and weaknesses for SMEs

In this Chapter the underlying strengths and weaknesses are described of SMEs active in the Dutch sector that focus on the digitalization of manufacturing. This is not an exhaustive list of strengths and weaknesses, but these are the ones highlighted during the survey. They partially clarify why the sector active on the digitalization of manufacturing and especially its SMEs (which is 97%[26] of the sector) did not reach the full potential yet. The results are based the aforementioned survey among Dutch SMEs active in the digitalization of manufacturing and they are supported by desk research. 1634 small and medium sized enterprises were selected for this survey based on a number of criteria:

- Selected from the Innovatiespotter[27]
- They fall under the SBI codes specified in Chapter 2 (see Table 3.1).
- Additionally, these enterprises were selected when they had an 'innovative footprint'. This means that an enterprise received an innovation nomination, prize or an award, and/or is a member of an innovation network or cluster or an association, and/or received a subsidy.[28]
- After that, organisations were filtered on having an e-mail address while removing the duplicate email addresses.

After sending reminders in total 38 respondents filled out the survey.[29] This low response rate means that we treat the results with care and complemented them with desk research and input provided by experts.

Most respondents who filled out the survey are from Gelderland, Noord-Brabant and Zuid-Holland. These are the regions with a lot of initiatives focusing on the digitalization of manufacturing. Based on the survey results 3 main strengths and 3 main weaknesses have been identified and will be discussed in this Chapter.

4.1 Strenghts

The strenghts that came out of the survey are:

1. *Familiarity with the digitalization of manufacturing,*
2. *Willingness to do more with the digitalization of manufacturing and,*
3. *Openness for a collaborative approach.* They are discussed in more detail in the next sections.

4.1.1 Familiarity with the digitalization of manufacturing

The Chamber of Commerce measured already in 2020 that 62% of the entrepreneurs (often SMEs) in the industry heard about the digitalization of manufacturing (based on the term Smart Industry) and 44% really knows what it means.[30] Our survey indicated that 96% of the SMEs is familiar with the digitalization of manufacturing. About 73% of the respondents indicate that they are active with the digitalization of manufacturing. Active means that activities are mainly undertaken for data collection and export, and automation of production and associated processes. The majority (62%) of these SMEs are cooperating with other companies in order to realize their developments to digitalize their manufacturing activities.[31] 57% of these SMEs have experience with Flexible production followed by 48% who has experience with digital factory. Both are transformations focused on the inside of the factory. For more details about various digitalization of manufacturing transformations with which the SMEs have experience see Figure 10.

26 Statistics Netherlands, National Accounts, Q2 2022
27 www.innovatiespotter.nl
28 www.innovatiespotter.nl gathers information on the SMEs in the Netherlands making profiles with data from hundreds of different public sources. Specifically the distinction is made between the following categories of innovation footprint: nominations and awards/awards; investments; networks: memberships/participations in (innovation) networks, innovation clusters, industry organisations and collaborations; startup programmes: incubators, accelerators and other incentive programmes for startups and scaleups; grants or subsidies received by the company (including RVO, RAAK, energy innovation grants, Interreg). For more details please refer to the Innovatiespotter Manual 2021.
29 Based on further analysis of the survey results.
30 Evaluation Smart Industry Dialogic (2021)
31 Ibid

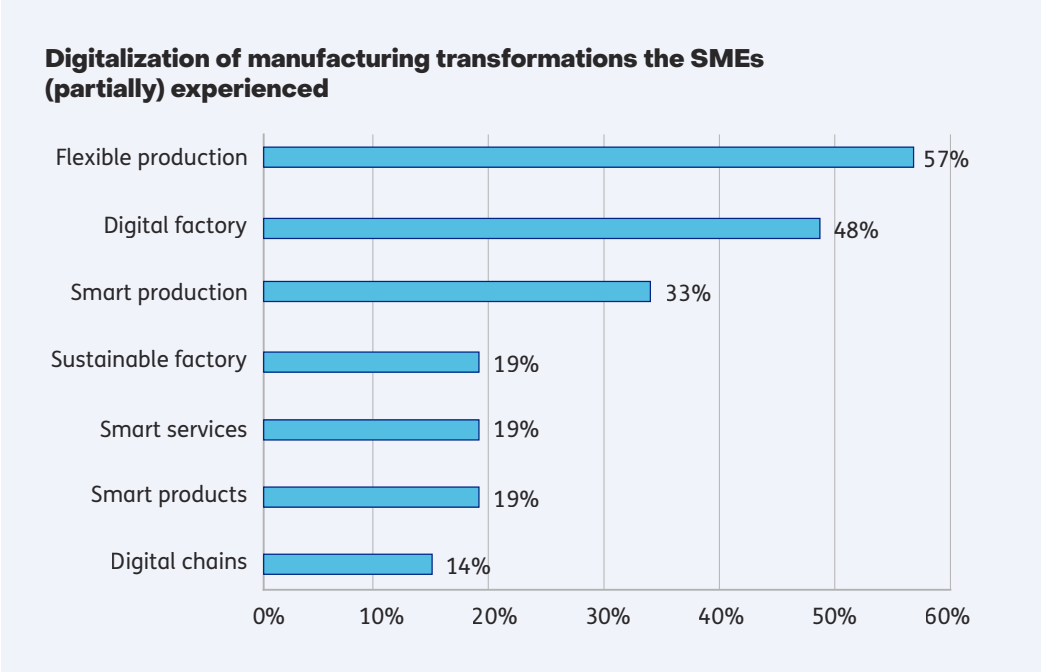

Figure 10 Digitalization of manufacturing transformations the SMEs (partially) experienced

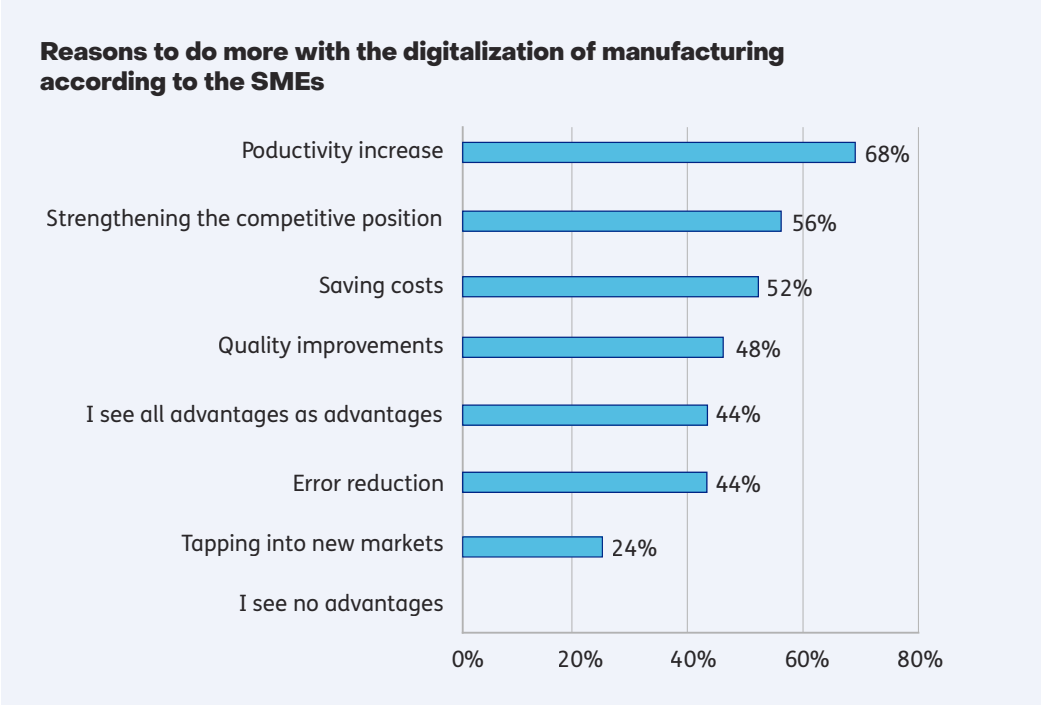

Figure 11 Reasons to do more with the digitalization of manufacturing according to the SMEs

4.1.2 Willingness to do more with the digitalization of manufacturing

The majority of the SMEs in our survey indicated that they want to do more with the digitalization of manufacturing for various reasons such as; productivity increase, strengthening the competitive position, saving costs and quality improvements etc. (see Figure 11). No one indicated that they see no advantages.

These results are in line with the investigation from ING about the digitalization of manufacturing value chains that focus on the fact that digitalization of manufacturing value chains contributes to lower failure and transaction costs, better quality etc.[32]

Our survey also shows various topics on which the SMEs aim to make more progress with, with in the top two 1. knowledge and skills development and 2. creating a space for testing with applications (see Figure 12). It is remarkable to see that a lower number of SMEs wants to make progress on the sharing of data and the digital connection with other companies.

4.1.3 Openness for a collaborative approach

SMEs often have a lack of resources to make progress with the digitalization of manufacturing. Therefore, SMEs often work in cooperation with other partners such as in national or European projects or via field labs (only two respondents of the survey reported to be active in field labs) or other public private partnerships.[33] Important partners they cooperate with are according to our survey complementary partners such as suppliers and peers.

4.2 Weaknesses

Next to the strengths there are various weaknesses. There is first of all a challenge that applies to the whole Dutch manufacturing industry. This sector has an average digital intensity that is slightly below average of all sectors.[34] As in other sectors, the share of companies with a high to very high

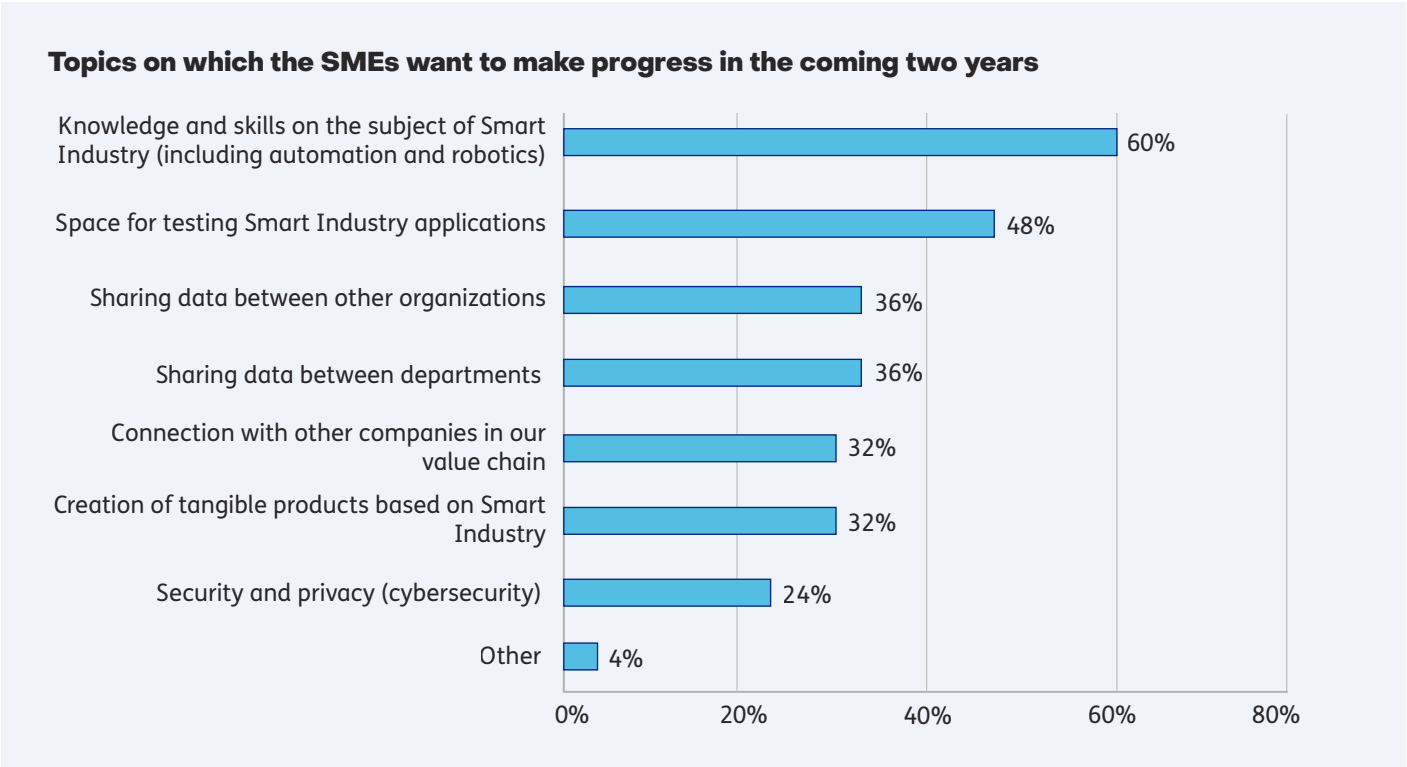

Figure 12 Topics on which the SMEs want to make progress in the coming two years

32 Digitalisation in manufacturing value chains ING
33 Verkenning EZK-perspectief benutting Fieldlabs
34 ING-Research-Digitalisering-van-industriele-productieketens

digital intensity increased faster during the corona years than before.[35] However, the industry is still lagging significantly behind sectoral frontrunners such as ICT, the energy sector and a part of business services.[36]

When focusing on the SMEs in particular we see the following weaknesses based on our survey;
1. Lack of awareness about national and regional initiatives,
2. SME perceive the digitalization of manufacturing as a challenge,
3. A large amount of partner organizations is less digitalized.
Each of these weaknesses are discussed in the next sections.

4.2.1 Lack of awareness about national and regional initiatives

Although many SMEs are active with the digitalization of manufacturing, many SMEs (68%) in our survey are not familiar with "Smart Industry", the initiative on national level for the digitalization of the manufacturing sector. These SMEs do not know for instance the events and workshops organized by the program bureau Smart Industry. Various of these SMEs are also not familiar with the initiatives on regional level (such as EDIHs, field lab initiatives, activities that took place in SMITZH or the Smart Industry activities in the Brainport region).[37]

Besides that there is a large number of parties that focus on promoting digitalization for SMEs in the manufacturing domain and beyond.[38] Such as regional development agencies, industry associations and knowledge institutions. Yet many SMEs do not know where they can go with their question – there is still no 'logical counter' and there is a lot of fragmentation.[39, 40] This creates the risk that it remains difficult for SMEs to find the appropriate support and that resources become less efficient allocated.

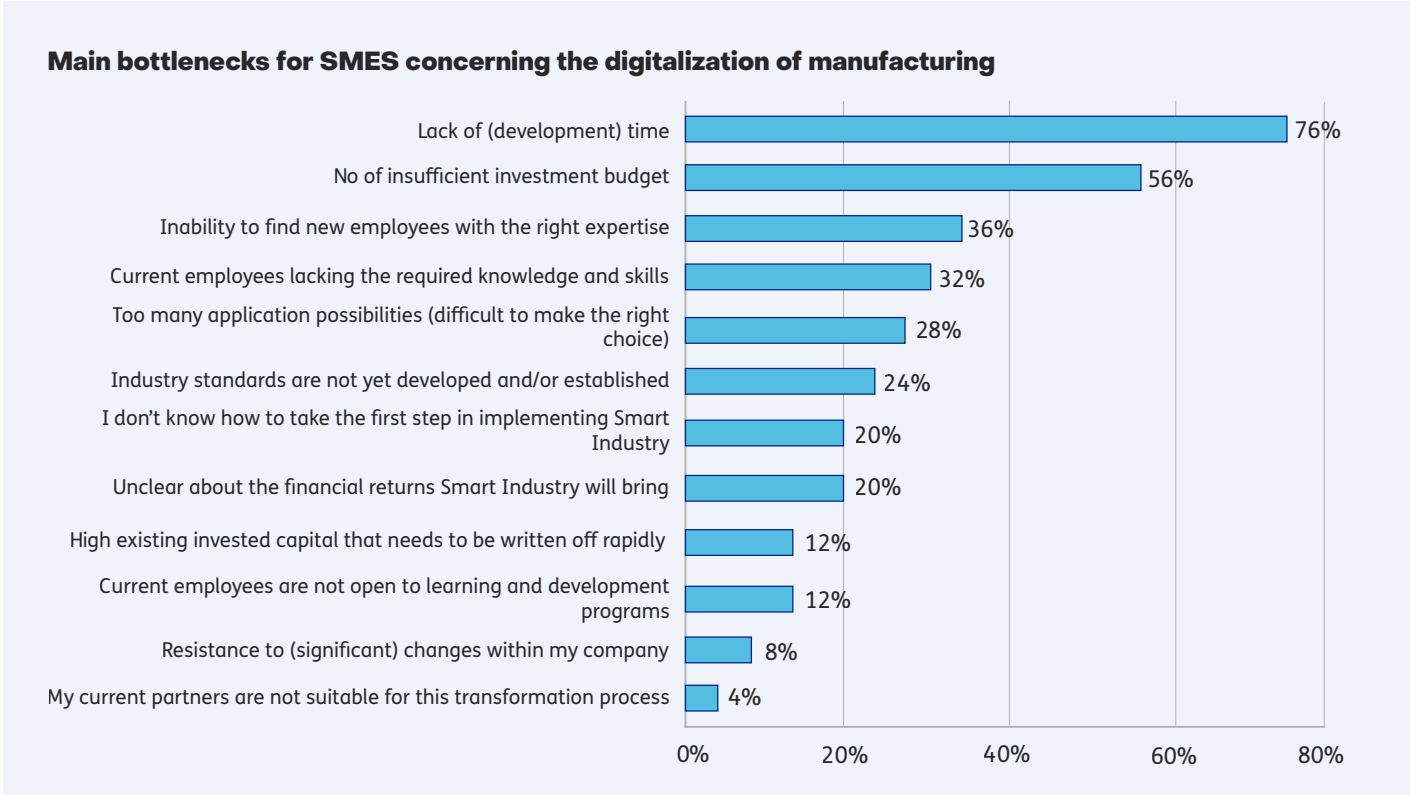

Figure 13 Main bottlenecks for SMES concerning the digitalization of manufacturing

35 ING-Research-Digitalisering-van-industriele-productieketens
36 ING-Research-Digitalisering-van-industriele-productieketens
37 Based on our survey
38 Stolwijk and Punter (2023), Smart Industry als katalysator van digitaliseringsproposities
39 Ibid
40 Based on expert interviews

4.2.2 Digitalization of manufacturing perceived as a challenge

Although many SMEs see the digitalization of manufacturing as an opportunity, 50% of the respondents in our survey sees it as a challenge and opportunity. That the digitalization of manufacturing is a challenge for them has various reasons. The figure below shows that SMEs are most often confronted with a lack of development time (76%) or they have to deal with an investment budget that is too small (56%) to continue developments related to the digitalization of manufacturing (for more details about other weaknesses see Figure 13).

There are financial instruments for SMEs in case of too low budgets. However previous investigations indicated that SMEs have to deal with various financing obstacles when they try to acquire subsidies, such as[41]:

- The high administrative burdens and (often) shortage of actual financial advantage, for example, the innovation box is less effective for SMEs than for large companies.
- In addition, the WBSO for example does not subsidize certain ICT developments which does focus on innovations and development of new digital technologies. Such as Machine Learning and artificial intelligence, where the software is self-learning.

These results are in line with an investigation of IFS in Europe, Asia and North and South America among 160 manufacturing companies, which indicated that the manufacturing sector is not picking up the chances of digitalization. However, they mentioned some other reasons why companies are distracted from investing in the digitalization of the manufacturing domain such as[42]:

- Increasing labour costs (61%),
- Increasing raw material costs (42%),
- and supply chain issues (42%).

All these costs make companies reluctant to do further investments. Especially, when they do not have a clear view on the return on investment. According to IFS, 62% of their respondents have no idea of the return on investments in digitalization.[43] According to IFS, this means they run the risk of losing their competitive advantage. However, without transparency and measurable return on investments, it becomes increasingly difficult for manufacturing SMEs to scale their investments and come to tangible benefits.

The more digital initiatives deliver return on investment, the easier it is for organizations to justify further investments in digitalization of manufacturing.

- Also during the conversations with experts some additional challenges have been mentioned that are not addressed in the survey such as[44]:
- Fear of disturbing primary production process: SMEs are reluctant to change their primary production process since their current business model is based on that. They are afraid that the digitalization of manufacturing changes that primary process in such a way that it might hurt their business model.
- Cybersecurity concerns: Digitalization also requires proper cybersecurity solutions to avoid that an SME will be hacked. However, these cyber security concerns make some SMEs reluctant to invest in digitalization.
- Not the right timing: There are certain moments in time during which SMEs are less and other times during which SMEs are more likely to adopt technologies required for the digitalization of manufacturing. Moments on which they are more likely to adopt these technologies are:
  a. When they want to attract new clients,
  b. When they focus on new products,
  c. During a company take over,
- Very limited basic digitalization: A lot of SMEs have very basic company digitalization not in place (for instance ERP). That brings further developments out of reach.

4.2.3 Large amount of partners organizations are less digitalized

When diving deeper into the value chain of these SMEs, it appears that only 29% of their partners are more digitalized according to our survey. This is a big challenge. Since automated exchange of information regarding ordering, invoicing and production planning with suppliers and customers stimulates quality improvements and cost reductions.[45] However, a precondition is that the involved partners are properly digitalized to be able to cooperate in a digital way.

Another reason why it is important to have partners that are equally or preferably more digitalized is because the more digitalized partners can support the less digitalized partners in increasing their digital maturity level.[46]
The next Chapter gives on overview on how these weaknesses can be mitigated.

41 Stolwijk and Punter (2023), Smart Industry als katalysator van digitaliseringsproposities
42 www.vraagenaanbod.nl/maakindustrie-pakt-kansen-digitalisering-niet/
43 Ibid
44 Based on expert consultations
45 ING research
46 Stolwijk, Karanikolova, Timan (2020), Digitizing Global Value Chains in a volatile world: Europe's opportunity, TNO report, TNO 2020 R10753

5 Conclusion and measures

In this Chapter the following research questions will be answered:

1. What are the most important developments for the digitalization of the manufacturing sector in the Netherlands? (see 5.1)
2. What is the current status of the digitalization of the manufacturing sector in the Netherlands? (see 5.1)
3. How can we accelerate the uptake of the digitalization of the manufacturing sector in the Netherlands, especially for the late adopters? (see 5.2)

5.1 Concluding summary

Currently, we are in the fourth industrial revolution that contains the following developments:

- It provides us technologies such as IoT, cloud computing, additive manufacturing, robotics, augmented reality, smart factories, data analytics, and artificial intelligence to automate the factory processes further.
- It also turns supply chains in to supply networks enabled by digitalization and the digital connections between companies.

The more future oriented industry revolution is Industry 5.0, which contains the following developments:

- It brings in personalization on top of the technologies covered in Industry 4.0, and it leads to a cooperation among humans and machines.
- Will bring in sustainability, clean energy, upcycled materials and decarbonization.

The Dutch manufacturing sector is not sufficiently digitalized although:

- It is the fastest growing sub-sector within the Dutch economy since 2016.
- Has a high R&D intensity and export rate.
- The sector is more advanced than in Germany.
- The Netherlands has a relatively high average labour productivity (€105.700 per person employed in 2021) compared to this sector in other EU Member States such as: Italy (€72.100 per person employed in 2021), Finland (€91.500 per person employed in 2021), Germany (€79.600 per person employed in 2021) and France (€81.400 per person employed in 2021).
- Three strengths have been identified for SMEs in this domain:
  - Most of them know what the digitalization of manufacturing means.
  - They are willing to do more with it.
  - They are open for collaboration with others to compensate for their lack of resources.

But Sweden, Ireland, Denmark and Belgium performed better over the years.

- The lower performance of the Netherlands could be explained by the fact that 59% of the enterprises in the Netherlands did not digitalize their manufacturing processes yet.
- 97% of the enterprises in this sector is SME, for whom this transformation is more challenging than for larger companies.
  - Smaller European countries such as Sweden and Ireland are more digitalized when the number of companies are concerned. Former investigations indicate that the success of especially Nordic countries relates to their focus and guidance on the more social issues of this digital transformation (e.g., such as the cultural acceptance and community engagement when implementing technologies).

5.2 Measures

This investigation indicates 3 weaknesses for Smart Industry SMEs that needs to be mitigated:

1. **Large groups of SMEs are not familiar with or involved in the national and regional Smart Industry initiatives, meaning that:**
- More awareness creation is needed about the work of the national program bureau Smart Industry and regional initiatives such as the European Digital Innovation Hubs.

2. **Smart Industry is perceived as a challenge by SMEs, because of a lack of time, budget and limited insights in the return of investments etc. This requires:**
- One clear contact point where SMEs can go to with their requests.
- This contact point should be able to provide clear guidance and advice on where to go to for content related advice, financial advice (e.g., on financing instruments and return on investments) or advice on cooperative initiatives such as field labs and European Digital Innovation hubs, that can stimulate the growth of their digital maturity.
- Policy instruments to stimulate the innovation ecosystem with which the SMEs can work on R&D and innovation.

3. **A large number of partners organizations is less digitalized, which is hindering the digital supply chain cooperation.** That requires:

- Providing dedicated support to SMEs by paying attention to the social aspects of the digital transformation such as the cultural acceptance and community engagement when implementing technologies (e.g., data analytics, AI etc. etc.).
- Frontrunners to support the followers and late adopters in the digitalization of their supply chain, since this will be of advantage to all the involved stakeholders, as it contributes to making their supply chain more transparent and efficient.
- Providing more access to capital and the capital market for SMEs in financing innovation, by taking away information asymmetry and obstacles.[47] This can be done by focusing on an accessible financing schemes for SMEs such as the innovation box, for which and effective tax advantage could be obtained to make it more useful for SMEs than it currently is.[48]
  (i) The European Digital Innovation hubs to:
  monitor the progress that SMEs made based on the support they gave.
  (ii) monitor which support has been most helpful for the SMEs and what support not, to be able to take corrective measures concerning the support provided to SMEs.

47 Versterken innovatief vermogen mkb: geen woorden, maar daden. - Bulletineke Justitia (bjnijmegen.nl).
48 www.subvention.nl/ict/nieuwe-subsidiemogelijkheden-ict-door-wijziging-definitie-programmatuur-wbso/.

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