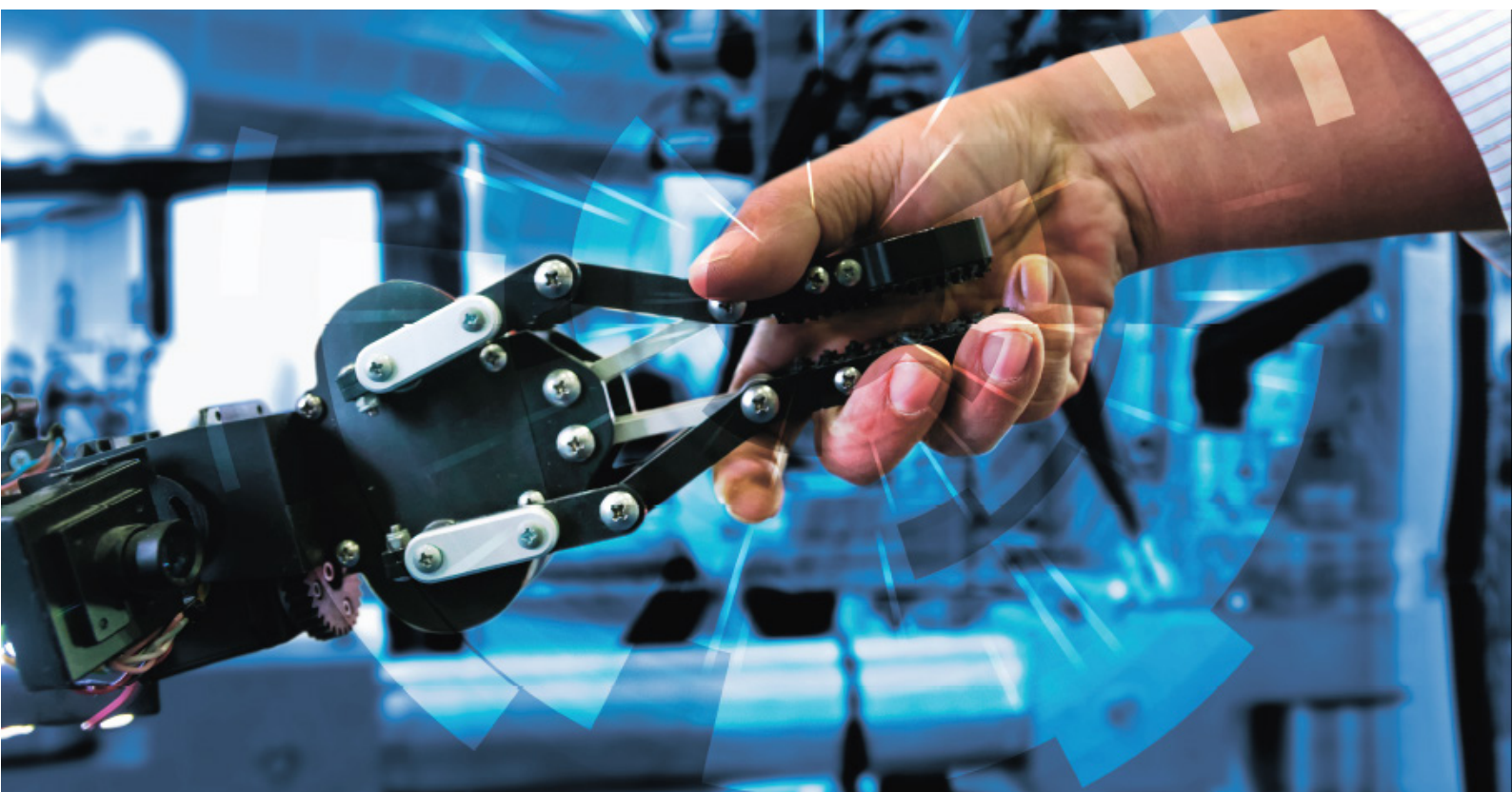




Industry 4.0 – opportunities and challenges for SMEs in the North Sea Region

Desk study - December 2018





Abstract

The rise of new digital industrial technology, known as Industry 4.0, is a transformation that makes it possible to gather and analyse data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This manufacturing revolution will increase productivity, shift economics, foster industrial growth, and modify the profile of the workforce—ultimately changing the competitiveness of companies and regions.

This desk study reports on the drivers of and barriers to the adoption and exploitation of Industry 4.0 technology by industrial SMEs. It also examines the specific issues facing the North Sea regions and the support that is in place to facilitate increased uptake. The report is compiled from major consultancy and government as well as regional reports on the subject of Industry 4.0. In other words, it constitutes the point of departure for the GrowIn 4.0 project.

The desk study finds that the partner regions face many of the same challenges but also opportunities in regards to industrial SMEs' uptake of Industry 4.0 technologies and business models. Many of these SMEs are moving toward the fourth industrial revolution - Industry 4.0 - which is regarded as the industry of tomorrow. A common challenge is e.g. the SMEs' lack of resources, skills and time for Industry

4.0. General obstacles for SMEs in the partner countries are lack of business support, a high degree of over cautiousness when it comes to investments in Industry 4.0, a lack of the right competences, a lack of digital standards, threats through cyber security, lack of finance, and finally lack of the right business tools. However, common opportunities are e.g. increased productivity, competitiveness and growth. General drivers across the partner countries are changing market needs, new technologies, regulatory interventions, and firm internal drivers.

If the manufacturing industry in the NSR is to remain competitive, we need to capture the potential for productivity and growth that Industry 4.0 appears to offer. There is a profound need for an experience based and smart gathering of efficient methods, tools and knowledge to guide industrial SMEs in their transformation towards Industry 4.0. This is what the GrowIn 4.0 project will work on for the rest of the project period. GrowIn 4.0 aims to build strong competences and tools in the participating regions for the benefit of manufacturing SMEs. In other words, our aim is to develop tools that can help the North Sea Region SMEs in regards to Industry 4.0. The approach is to establish a strong partnership which pools knowledge on the manufacturing industry and Industry 4.0.



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1 Introduction

In the following section, we will introduce the GrowIn 4.0 project, its work packages and their relation to each other. Finally, we will show how the project operationalizes Industry 4.0 and present a definition of Industry 4.0.

1.1 GrowIn 4.0 – project description

The Interreg North Sea Region (NSR) project GrowIn 4.0 aims to build strong competences and tools in the participating regions for the benefit of manufacturing small and medium-sized enterprises (SMEs). The overall objective is to raise the level of innovation and to create more growth within manufacturing SMEs who are heading for Industry 4.0. SMEs (enterprises employing fewer than 250 persons) represent 99 % of all businesses in the EU (Eurostat 2018). The EU Commission fears that the European SMEs are falling behind their American counterparts in the implementation of Industry 4.0 (McKinsey & Company). The project is working within the following three work packages:

New business models and strategy development

The focus of this work package is to strengthen the business strategies and business models of manufacturing SMEs in the context of the opportunities and challenges of Industry 4.0. This is an important precursor that will enable SMEs to assess, improve and adapt their innovation strategy. It will also help them understand how to align their capabilities to their market environment and which aspects of Industry 4.0 will be important for sustaining their competitive advantage.

Better use of technology and development of products

The focus of the this work package is in particular to transfer knowledge with Industry 4.0 technologies between knowledge institutions and SMEs. This is necessary in many respects. For SMEs, the risk is particularly high to use new technologies without having any experience with them. On the other hand, it is indispensable for the competitor to remain technologically at a progressive level.

Training, education and recruitment of Industry 4.0 qualified staff

The focus of this work package is to increase the level of skills and knowledge needed for implementation of Industry 4.0 in SMEs. Technology associated with Industry 4.0 like Big Data, Internet of Things (IoT), Robotics, Additive Manufacturing offer many opportuni-

ties for manufacturing SMEs. There is a special focus on how to help the SMEs to develop the required human capital: workers with the right knowledge and competences to apply Industry 4.0 technologies. The required knowledge and competences are not exclusively digital but also more soft competences: e.g. cooperation, networking, branding and teambuilding.

To sum up, the North Sea regions cooperating in this project want to develop a regional approach to help their individual SMEs, their owners, their workers (and the currently not-employed), and the entire regional economy respond to changing opportunities – and jointly reap their economic and employment benefits.

1.2 Definition of Industry 4.0 in the project

In the GrowIn 4.0 project, we see Industry 4.0 as a three-part concept. This is also reflected in our three work packages. First, Industry 4.0 is also about new business models, new organisational structures, and new ways of collaborating. Second, Industry 4.0 is about innovations and technological (IT) possibilities. Third, it is also related to new skills, further training of the existing work force, and new courses/educations.

To elaborate, the UK Industrial Digitalization Review Interim Report (UK Industrial Digitisation, 2017) defines Industrial Digitalisation as the application of digital tools and technologies, in all their forms, to the value chains of businesses who make things (e.g. automotive and construction) or are operationally asset intensive (e.g. power grids, wind farms etc.). It is the merging between the physical and digital worlds to significantly enhance performance and productivity.

The underlying concept of Industry 4.0 is to connect embedded systems and smart production facilities to generate a digital convergence between industry, business and internal functions and processes. Within the modular structured 'Smart Factories' of Industry 4.0, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, Cyber-physical systems communicate and cooperate with each other and humans in real time. Via the Internet of Services, both internal and cross-organizational services are offered and utilized by participants within the value chain.



There are a variety of supporting industrial organisational technologies (IDT) – e.g. artificial intelligence, 'Internet of Things', robotics, cheap battery operated sensors and analytics – but fundamentally it is the integration of these cyber and physical technologies into production and logistics that is allowing new businesses to form, integrate and strengthen supply chains, and allow productivity gains to be realized. The application of these known and emerging technologies will continue to disrupt companies as they adapt to customer centric business models, offering enhanced products and services (Made Smarter, 2017). And – as mentioned above – this demands new skills both for students and the existing work force.

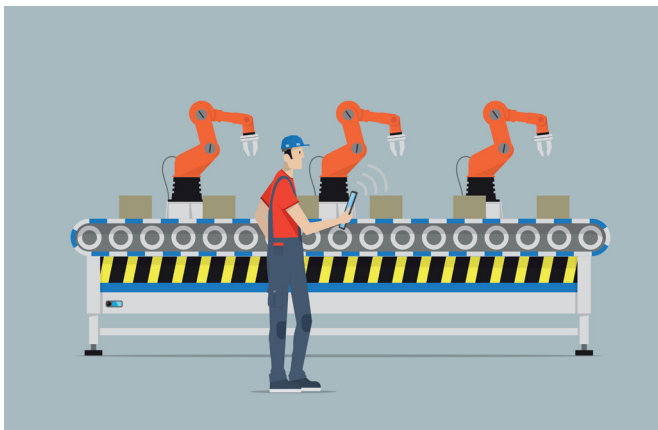


2 Generic drivers and obstacles for Industry 4.0 in manufacturing SMEs

In the following section, we will present what the partner regions experience as generic drivers and obstacles for SMEs to utilise Industry 4.0 in their manufacturing factories.

2.1 Drivers

Firm internal drivers: For manufacturers, the main drivers for investing in Advanced Manufacturing Technology (AMT) are largely internal, for example, reducing production costs, improving the quality of products and services, improving the employee productivity and reduction of production lead time (European Commission, September 2016). Digital technologies also create opportunities for differentiation in the marketplace, for enhancing the efficiency of the production system and improving on-time performance (Cologne Institute für Economic Research (IW), FIR at RWTH Aachen University, page 17).



Regulatory intervention: Some industries, like construction, have been pushed down a compliance route by government procurement. However, regulatory intervention has been rare on the assumption that individual firms will benefit from adopting digital technology. Other sectors where regulation over standards may become important are e.g. health provision, on environment and sustainability.

Changing market needs: There is perceived to be a growing demand for the personalization of mass produced products. Smart automation can achieve this economically as connected factories, can deliver greater variation for customers still at high volumes, while simultaneously increasing speed and reducing

waste. Companies themselves will need to be more agile in changing product iterations and varying demand volumes in the future as consumer tastes or design intent changes mid-run.

Technology drivers: In the last ten years, the cost of sensors, cloud infrastructure, bandwidth and processing power has dropped significantly. Cutting-edge technologies are moving into mainstream manufacturing making the implementation of industry 4.0 more relevant and applicable to manufacturing industry (The Boston Consulting Group, November 2016).

2.2 Obstacles

Low rates of adoption of Industry 4.0 thinking and technology by SMEs is a particular problem for the overall industrial development in all European regions. Firm size is a key factor in willingness to engage with industry 4.0 technology, with smaller firms being less willing (Stentoft, J., Rajkumar, C., & Madsen, E. S., 2017). Although, it should also be noted that SMEs, at least in Germany, are regarded as ‘hidden champions’ accounting for 22 of the top 100 machinery and plant manufacturers (Industrie 4.0. Smart Manufacturing for the future).

There are a number of reasons identified for this, some of which point to the sorts of solutions this research can engage with:

Support: there is a lack of business support and best practice guidance for adopting new technologies (European Commission, September 2016)

Overcautious: Companies in the North Sea Region are still very careful when it comes to investing in Industry 4.0 related R&D (McKinsey Digital, 2015: 16).

Work force: There is a shortage or lack of proper access to people with the right skills and in the level of systematic engagement with the skills education/training that could sustain these fast-moving changes. Respondents in the UK rated a shortage of qualified staff as the most important of the challenges facing their companies, with nearly one third stating it was a “big or very big” challenge. (Cordes and Stacey 2017; European Commission, September 2016). In Germany a particular issue, process and control know-how for employees, was identified (McKinsey



Digital, 2015). Technically skilled managers will also be key (Made Smarter, 2017) along with improved training and competence development (Stentoft, J., Rajkumar, C., & Madsen, E. S., 2017; Made Smarter, 2017).

Standards: The slow development of digital standards risks fragmentation (UK Industrial Digitisation 2017, BCC, 2017). Firms need standardised networking for their production resources (many still have proprietary systems).

Security: Concerns over and confidence around the managing of cyber security is seen as an issue for many firms. (UK Industrial Digitisation 2017, BCC, 2017; McKinsey Digital (2015). These findings point out, that data security is a big issue, when it comes to implementing Industry 4.0 (McKinsey Digital (2015): Industry 4.0).

Available finance: There is a high cost of investment, and lack of financial resources (European Commission, September 2016).

Investment: According to the McKinsey survey, only 15% of the total R&D budget is invested in field con-

nected to Industry 4.0, even though Industry 4.0 already makes up 19% of total revenue (McKinsey Digital, 2015: 16).

Business tools: there are difficulties in assessing the performance and potential in terms of business return (European Commission, September 2016).

Summing up on some of the relevant recommendations highlighted in the European Commission, September 2016 report and in the “Progress in demand” project (NORDPLUS Adult and Association of Nordic Engineers, ANE) it was clear that there was a need to strengthen capacity for SMEs, in particular by building a stronger readiness in SMEs to look for collaboration with knowledge institutions, and develop the mediating role for the knowledge institutions in this form of collaboration. SMEs also need better access to information to stimulate technology transfer. SMEs need web-based information on available technological knowledge, access to knowledge networks among SMEs and a better understanding of business models for technology firms. They also need better financial support and better demonstration environments regionally, nationally and internationally (European Commission, September 2016).



3 Current situation

In the following section, we will describe the current situation and tendencies in the partner regions in regards to technological innovations, skills and knowledge, and readiness of SMEs to adapt to Industry 4.0.

3.1 Technological innovations within Industry 4.0 – key technologies and use of these in SMEs

Advanced digital technology is already used in manufacturing, but with Industry 4.0, it will transform production. It will lead to greater efficiencies and change traditional production relationships among suppliers, producers, and customers — as well as between human and machine.

Nine technology trends form the building blocks of Industry 4.0 – these are:

- Autonomous robots
- Simulation
- Horizontal and vertical system integration
- Internet of things
- Cyber security
- The cloud
- Additive manufacturing
- Augmented reality
- Big data and analytics

None of the partner regions have an industrial sector that is a 100 % transformed to Industry 4.0 and therefore all regions are interested in helping their companies with the transformation.

To get an overview of all five partner countries we have had a look at the key findings of the World Economic Forum's Global Competitiveness Report, which is published October 2018. According to the report, which in 2018 uses a brand new methodology to fully capture the dynamics of the global economy in the Fourth Industrial Revolution, many of the factors that will have the greatest impact in driving competitiveness in the future have never been the focus of major policy decisions in the past. These include idea generation, entrepreneurial culture, openness, and agility. The new tool maps the competitiveness landscape of 140 economies through 98 indicators organised into 12 pillars. For each indicator, using a scale from 0 to 100, it indicates how close an economy is to the ideal state or "frontier" of competitiveness. When combining these factors, Germany achieves the best overall performance compared with the other four partner countries with a score of 82.8 (A third place), a head of Netherlands (82.4/sixth place), United King-

dom (82.0/eighth place), Denmark (80.6/tenth place), and Belgium (76.6/twenty-first place) (World Economic Forum 2018). In other words, the partner countries have a good basis. In the following, we will have a closer look at each country/region.

A survey commissioned by Bitkom revealed that 46 % or nearly half of German manufacturing companies have implemented Industry 4.0 applications, and that an additional 19 % have concrete plans to implement them. This means that 65 %, or nearly two-thirds of German industrial companies are already engaging with Industry 4.0. Around one-fourth of survey participants (23 %) do not have concrete plans to implement Industry 4.0 yet, but can imagine that they would implement these sorts of applications in the future. Only 12 % of survey takers said that they are not or will not be interested in Industry 4.0. The data cover Germany as a whole, but it may be assumed that a similar distribution goes for Lower Saxony Region (Bitkom 2016).

In a similar survey commissioned by Central Denmark Region, the results revealed that 65 % of the regions companies use machines or gear that contains it equipment, and that most companies expect to invest in new technologies within the next 12 month – with the largest SMEs wanting to invest the most (KOBRA 2018, Statistics Denmark 2018). In the EU's ranking of Denmark at the highest level of digital intensity, 42 % of the enterprises are at a very high or high level of digitisation (Statistics Denmark 2018). However, it appears that Danish businesses are not quite as good at utilising the newest digital technologies for new business models and services. Danish enterprises are at an advance stage of using the basic technologies, but in regards of advanced technologies Denmark is not quite equal to the EU countries to which we usually compare ourselves in other fields (Statistics Denmark 2018). In general, only 5 % of Danish enterprises use machine learning and artificial intelligence, only 15 % use satellite-based services, and only 9 % use Radio-frequency identification (RFID) technology. The most used advanced technology among Danish enterprises is smart sensors and Internet of Things with 33 % of the enterprises using this (Statistics Denmark 2018).

In the Northern Netherlands Region a different approach has been taken. In 2015, the Northern Netherlands Alliance (SNN) and the University of Groningen



(RUG) started an ambitious project together; to develop a regional Innovation Monitor for the Northern Netherlands. The ambition was to build a system that draws upon the participation of a large amount of SMEs, as well as the adoption and support of key stakeholders from the entire 'Helix' (The Northern Netherlands Innovation Monitor). In 2018 the monitor investigated the degree of use of disruptive technologies. Internet of Things, sensor technology, robotisation and Big Data are relatively the most popular disruptive technologies within SMEs in the Northern Netherlands. Striking is that large and older SMEs are more active with disruptive technologies than, for example, high-tech start-ups (Faems and Wennink 2018).



In Flanders, Industry 4.0 is one of the seven “Transition Areas” in which Flanders aims to make considerable progress over the coming 7 years. Flanders has already taken different initiatives in regards to Industry 4.0. The strategic Research Centre Flanders Make (started in 2014), the activities within iMec and the research conducted at the five Flemish Universities are examples of such initiatives. Belgian and Flemish companies already score relatively well on the Digital Transformation Scoreboard (re: Roland Berger, 2014). In 2016 Flanders Make and Price Waterhouse Cooper have conducted a study among 30 companies in Flanders. Both big companies as well as SMEs were interviewed about their approach to Industry 4.0. One of the results was that Flemish companies have a certain confidence level that they can manage the new technologies related to Industry 4.0. However, finding the right people is the main concern.

To sum up, across the partner regions many SMEs have started to use Industry 4.0 technologies and even more SMEs are interested in doing so.

3.2 Skills and knowledge regarding Industry 4.0

In all partner regions, SMEs feel the need to develop Industry 4.0 skills and attract relevant personnel. Especially IT specialists are needed for the company's transformation into a digital age and in regards to purchasing new technologies and IT systems. Information about IT specialists is an indicator of companies' degree of digitisation, and an analysis of Statistics Denmark states that innovation and more digitization require, that the company must have its own IT specialists employed. There is no doubt that the need for IT specialists is growing (Danske Regioner 2018).

However, it is a general problem across all partner regions to overcome labour shortages in IT-skilled personnel. The Northern Netherlands - where the city of Groningen has risen to the 2nd IT city in the nation after Amsterdam and is closing in - experience a shortage in IT human capital in general (cf. van Lieshout et al. 2017), and Industry 4.0 competences in particular. Almost 16 % of Dutch industrial companies say that the lack of staff hampers production. The problem is greatest in the machine industry. Nearly 16 % of industrial companies says that the lack of personnel leads to bottlenecks in production (Statistics Netherlands December 2017). ING's research shows that by 2030 the Dutch technology industry needs about 120,000 people; 70,000 people because of retirement and 50,000 people to keep the growth of the industry (Volkskrant 8 December 2017). Therefore, The Hanze UAS has teamed up with IT employers to develop an IT Academy stimulate training for IT employees, and is currently developing a program to retrain professionals from other fields for IT employment.

The Cambridge-Peterborough Region feels increasingly dependent on highly skilled workers and has problems to find these workers. The experiences in the Lower Saxony Region and also in Flanders are similar: it is difficult for SMEs to find the right employees for IT work in general and I4.0 employment in particular.

In Central Denmark Region, within IT, engineering, industrial production and science it is every fifth company, which have problems with recruitment. The group counts qualifications in programming, software development, electronics, plastics engineering, robot engineering, automation, biotechnology, ma-



thematics, food and pharmaceutical science. Every third company is experiencing challenges in recruiting IT specialists, which are working with software development or other coding or are maintaining IT systems. The Danish Ministry of Industry, Business and Financial Affairs predicts that Denmark will lack 19,000 IT specialist by 2030 (Højbjerg Brauer Schultz 2016). Skilled workers are hardest to recruit. More than every second company has had trouble recruiting skilled workers. Companies in Central Denmark Region are expected to employ more people with a vocational education. Projections show that Denmark is going to lack 26,000 skilled workers in 2025. In Central Denmark Region, there will be a lack of 9,000 skilled workers. (Danske Regioner 2018). A brand new analysis of manufacturing enterprises' need for skilled and unskilled employees with digital competences in the region shows that more than every fifth SME has a current need for skilled or unskilled staff with digital competences (Mploy 2018). And that more than 40% expect a need in the future.

A similar situation is found in Flanders. In a recent Belgian study Agoria (the technology federation), together with the employment services VDAB, Forem and Actiris, mapped the major trends on the labor market until 2030. They found that the digitisation will lead to fewer jobs, but for every job vacancy that will be lost in the future, 3.7 new ones will be added. The study also showed that due to the structural shortage of workers and insufficiently adapted skills, on average 1 in 10 vacancies (11%) in Belgium will not be filled in 2030. In July 2018, the social partners in Flanders formulate a whole series of recommendations and actions to tackle the transition to a digital society together with the Flemish Government and other actors. These recommendations should form the basis for a possible digital agenda for Flanders.

3.3. Readiness of SMEs to adapt Industry 4.0

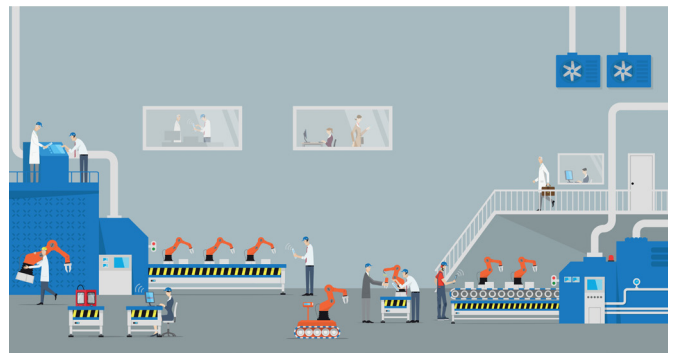
As mentioned in section 2.2, the partner regions experience some generic obstacles in regards to SMEs adaption of Industry 4.0 technologies as well as business models.

In Lower Saxony Region, a report by the Cologne Institute für Economic Research suggests that companies in the region need to show a more innovative spirit, a higher propensity to adapt their strategies and be prepared to experiment. Similar, both in Central Denmark Region and in Cambridge-Peterborough Region there is a poor adoption – particularly among

SMEs.

In Central Denmark Region, it is mainly large companies that are digitalised, with around four out of five being highly digitalised. On the other hand, only about 30 % of SMEs with 10-19 employees are highly digitalised. In 2012 around 36 % of Danish SMEs had a very basic level of digitalisation, 40 % had a wider use of digitalisation, 17 % used advanced digitalisation whereas only 7 % used digitalisation business concepts (Iris Group, Digitalisering af dansk erhvervsliv, 2013). Probably, these figures have changed substantially since 2012, but it is still recognised that the level of digitalisation is low in most SMEs.

In Cambridge-Peterborough Region, SMEs in particular perceive significant barriers to adoption, such as risks around cyber security, a lack of common standards allowing different technologies to connect, and access to funding to support investment.



Furthermore, several of the partner regions underline the need for regional support agencies that can help the SMEs to adapt to Industry 4.0. Both in Lower Saxony Region and Central Denmark Region such agencies are already in place, and in Cambridge-Peterborough Region they have started to establish a favorable support infrastructure. However these innovation assets are under-leveraged and not focused enough on supporting SMEs, meaning that the region is falling behind in the creation of new innovative companies and industries.

A similar pattern is seen in the Northern Netherland Region and The Netherlands in general. The Dutch manufacturing industry is strong in providing tailor-made work based on an intensive customer relationship, but it certainly has excellent companies in mass production as well. In the area of digitization, the Netherlands has numerous companies at the



forefront (Dutch Ministry of Economic Affairs 2016). According to the World Economic Forum's 'Networked Readiness Index' the Netherlands is second best in the world, just behind Singapore (Dutch Ministry of Economic Affairs 2016). This index is a key indicator of how countries are doing in the digital world. But, behind the companies at the forefront, there is still a world to be captured. A recent study by the Dutch national government has shown that a significant number of entrepreneurs are still relatively uninformed about the upcoming digital revolution and its implications for their business (Dutch Ministry of Economic Affairs 2016).

The same 'Networked Readiness Index' of the World Economic Forum ranks Belgium at place 23. Until now there is limited coordination in the Flanders region and no overarching longer term vision on Industry 4.0 or a digital agenda in the broadest sense. However, different stakeholders have clear trumps to scale up the actions, to achieve more synergy and to put more companies on the road to Industry 4.0. A few actors

have already come forward through public grants and a high level of mobilisation from industry partners is visible. For instance: 265 companies are currently involved in a 'Factory of the Future' programme, out of which 65% are SMEs and 16 companies have already been awarded the label 'Factory of the Future'. With a modern and forward-looking approach and technological readiness, Flanders should be ready to develop Industry 4.0. However Flanders is lacking a strong industrial base as the industry in the region has had some blowbacks in the past decade. A survey done with entrepreneurs in the manufacturing industry states 70-90% of the respondents do not rule out cooperation with other companies and/or knowledge institutes. This testifies to a big willingness to go beyond the limits of one's own company. Entrepreneurs are advised through a variety of contacts: knowledge institutions, sector federations, advisors, etc. However, the research does not indicate how easy the manufacturing companies find the right contacts in their search for a sustainable cooperation.



4 Opportunities and challenges for the NSR in the future

In the following section, we will describe the opportunities and challenges for the North Sea Region in the future in regards to Industry 4.0.

4.1 Identified opportunities and challenges

When we look across all five partner regions, we find that Industry 4.0 advancement will bring benefits in four areas:

Productivity: Industry 4.0 will lead to increased productivity for the SMEs. Through the technologies mentioned in section 3.1 the SMEs can extract insights from their data to move from reactive to predictive maintenance, pinpoint improvements, reduce waste and increase yield. Furthermore, they can fine-tune quality management and thereby prevent costly rework.

Revenue Growth: Industry 4.0 will also drive revenue growth. Manufacturers' demand for enhanced equipment and new data applications, as well as consumer demand for a wider variety of increasingly customized products, will drive additional revenue growth.

Employment: The growth Industry 4.0 stimulates, will lead to an increase in employment. However, different skills will be required. In the short term, the trend toward greater automation will displace some of the often low-skilled labourers who perform simple, repetitive tasks. At the same time, the growing use of software, connectivity, and analytics will increase the demand for employees with competencies in software development and IT technologies, such as mechatronics experts with software skills. (Mechatronics is a field of engineering that comprises multiple engineering disciplines.) This competency transformation is one of the key challenges ahead.

Investment: Adapting production processes to incorporate Industry 4.0 will require that producers in all regions invest in new technologies and skills during the next years. This will lead to additional investments in the society in general.

On the other hand, we have identified the following challenges for the industrial SMEs across the partner regions:

- Define which business model to leverage for their enhanced or new offers.
- Build the technological foundation, such as the tool base for analytics.

- Build the right organization structure and capabilities.
- Develop partnerships that are essential in the digital world.
- Participate in and shape technological standardization.
- Upgrade technological infrastructure, such as fixed- and mobile-broadband services. Infrastructure must be rendered fast, secure, and reliable enough for companies to depend on it for near real-time data.
- Get the right skills and therefore adapt school curricula, training, and university programs and strengthen entrepreneurial approaches to increase the IT-related skills and innovation abilities of the workforce – as well as upgrade the existing workforce.

To sum up, Industry 4.0 allows for a faster response to customer needs than is possible today. It improves the flexibility, speed, productivity, and quality of the production process. And it lays the foundation for the adoption of new business models, production processes, and other innovations. This will enable a new level of mass customization as more industrial producers invest in Industry 4.0 technologies to enhance and customize their offerings (Boston Consulting Group 2015).

4.2 Most important sectors

The most important sectors within each partner region is summarized below.

Lower Saxony region

In Lower Saxony Region more than 4 million economically active people generated a GDP of EUR 276.3 billion in 2016. This value equalled 8.8 % of the overall German GDP in 2016. In the Braunschweig region more than 800.000 working people produced a GDP of EUR 68.5 billion. The contribution of the manufacturing sector amounted to 39.8 %, which was the largest share between all German NUTS2 regions. This emphasizes the great importance of manufacturing for the Lower Saxony region. Mainly driven by the automotive and mobility sector, other important industries are steel production and metal processing, health and medical engineering, mechanical engineering, food and beverages as well as the chemical industry.



Flanders Region

The backbone of Belgian industry - in a narrow sense - is formed by players who are mainly part of the chemical industry, the metal industry, the food processing and the production of electrical equipment. Together, these make up almost 80% of the industrial added value in our country, in other words, the production of these intermediary goods accounts for a share of almost 14 % of the total GDP. Flanders is favoured by an excellent central location within Belgium, with an important logistic hub, due to its central location and its dense and integrated multi-modal transport infrastructure. The Flemish network economy mainly derives its power from SMEs often acting as supplier companies. In addition, the petrochemical industry and ICTs are key sectors of the regional economy. Flanders covers 44.8 % of Belgium's territory and represents the majority of the country's industry and workforce; the region provides 58.7 % of the national gross domestic product (GDP).



The Northern Netherlands Region

The Dutch landscape exists of 2,932,643 companies. 0.5 % (14,188) of these companies are located in Northern Netherlands. 8,558 Companies in Northern Netherlands are manufacturing companies (Sizo Living Data 2018). This means that more than 60 % of all the companies in Northern Netherlands are manufacturing companies.

Manufacturing contributes significantly to the Dutch economy. This sector grew in the last quarter of 2016

with 2.1 % with respect to the third quarter of 2016. This is the highest growth for the manufacturing industry since 2011 (RaboResearch 2016). The private spending on R&D is 74 % and almost 80 % of the export exists of goods (Risk Solutions). 9.9 % of the national workforce is employed in this sector (Centraal Bureau voor de Statistiek). The graphic shows that in Northern Netherlands (Groningen, Friesland and Drenthe) more than 11 % of the workforce is employed in the industrial sector. Besides that, Industry is also a source of employment. It is estimated that for every new job created in this sector, one and a half job can be created in the service sector (Risk Solutions).

Cambridge-Peterborough Region

United Kingdom manufacturing is 9.8 % of the total economy (£162bn GVA in 2015) and the country is still in the top 10 largest manufacturing nations (9th 2016/17) and 4th largest in the EU. It employs 2.6 million people but close to 5.1 million across the manufacturing value chain. United Kingdom exports of goods produced by the manufacturing sector total £257 billion in 2015, and were 50 % of all UK exports. It accounts for 70 % of business R&D and 14% of business investment (UK Industrial Digitisation 2017).

Central Denmark Region

Manufacturing contributes significantly to the Danish economy with around 14 % of gross value added. Related to both exported goods and the private spending in R&D that counts for around 60 %. Business in Central Denmark Region (CDR) has 6 core sectors: Food, Energy and Climate, Smart Industry, Creative business, ICT and Tourism. Within all of these strongholds and especially within Food, Energy and Climate and Smart Industry, Industry 4.0 is fundamental as these sectors are within the manufacturing industry.

In general, since the North Sea Region is characterised by industries with a relative high level of product variants, e.g. automotive or food-and-beverage industries, the region will benefit from a greater degree of flexibility that can generate productivity gains, or industries that demand high quality, e.g. semiconductors and pharmaceuticals, will benefit from data-analytics-driven improvements that reduce error rates (Boston Consulting Group 2015).

4.3 Needs for skills and knowledge

The digitization of factories will change the jobs in manufacturing SMEs. The Future of Jobs Report from the World Economic Forum mentions the top ten skills



required from employees. These important skills are: 1) complex problem solving, 2) coordinating with others, 3) people management, 4) critical thinking, 5) negotiation, 6) quality control, 7) service orientation, 8) judgment and decision making, 9) active listening, and 10) creativity (World Economic Forum 2015).

The Association of German Engineers (VDI) and the American Society of Mechanical Engineers (ASME) studied the impact of industrial innovation on the role of labour in the future of manufacturing. They analysed different tasks and set up a list of qualifications and skills which will be important in the factory of the future. Two main outcomes of the research are: 1) the set of qualifications and skills needed in the factory will fundamentally change; and 2) in order to be successful in the manufacturing sector, a skilled workforce is needed (VDI and ASME 2015). The results are in the table below:

to fill jobs for those that leave the sector/occupations by new high school or college graduates, and (re) train their existing workforce to accommodate changing skill needs within their occupation.

Industry 4.0 affects and changes almost all jobs and occupations. And if this would not be enough of a challenge already: IT itself and the new technologies are still rapidly changing. The stereotypical image of IT work in general has radically changed almost by decade: from people in white overalls in large industrial halls with large mainframe computers in the seventies, to each white collar worker having a desk and a desktop as a personal workplace at the office in the nineties, to officeless-ly working in the cloud wherever you are these days, with the Internet of Things rapidly coming into focus for the future. Developing a quantitatively and qualitatively adequate workforce will remain an enormous challenge in the future. This will be elaborated below.

		Must...	Should...	Could...
		<i>... be included in the skillset of the skilled labor of the future</i>		
Technical Q&S	IT knowledge and abilities		Knowledge Management	Computer programming/coding abilities
	Data and information processing and analytics		Interdisciplinary / generic knowledge about technologies and organizations	Specialized knowledge about technologies
	Statistical knowledge		Specialized knowledge of manufacturing activities and processes	Awareness for ergonomics
	Organizational and processual understanding		Awareness for ITR Security and data protection	Understanding of legal affairs
	Ability to interact with modern interfaces (human-machine / human-robot)			
Personal Q&S	Self- and time management		Trust in new technologies	
	Adaptability and ability to change		Mindset for continuous improvement and lifelong learning	
	Team working abilities			
	Social skills			
	Communication skills			

However, skilled worker shortages in technical occupations and professions have proven a shared and persistent problem in European economies. While IT has attracted a growing share of youth for vocational, professional and academic education and training, the demand for skilled and professional IT employees has grown much faster. Traditional occupations – those that have existed for a century or more – have an abundant existing workforce. They basically only

4.4 Main barriers for developing skills and knowledge

By 2025, some jobs that are at the fringe today will be mainstream. Others will be obsolete. Already now, we must take a long-term view and structure the education system accordingly.

A first main barrier is the shortage of labour with the right skills and knowledge. Therefore, a first step is to



map out the specific competencies that will be required in science, technology and engineering over the next 10 years due to Industry 4.0 – from specialists to unskilled workers. In particular, we should expect an increase in demand for industrial data scientists, robot coordinators, industrial engineers and simulation experts, supply chain coordinators, digitally assisted field-service engineers, data-modeling specialists, and 3D-computer-aided design and modeling specialists, to name a few. As a next step, we need to understand the size of the gap. For this, a detailed forecast of the future workforce, in order to get an estimate of the gap between supply and demand across the various competencies will be needed. Yet this should not be a one-off event, but a continuous process, since the required skills will change over time (Boston Consulting Group 2016).

With a better understanding, the second barrier is to close the gap before it is too late. In addition to specific job areas, we should aim to educate both generalists and specialists, multidisciplinary skills in higher education and vocational training. To do this, we have to focus on building the right kind of capabilities, increase the number of newly educated people, add to the supply of fully-trained workers, and rethink traditional work models. In other words, we need to build a workforce that meets future demand, and we need to dramatically increase the supply of students with a technical background. The most critical challenge is the dwindling supply of IT specialists (Boston Consulting Group 2016).

Moreover, a final challenge is a brand new format for further education that emphasizes on going retrain-

ing of the existing workforce. Above all, universities and vocational colleges should add Industry 4.0-related topics to their curricula, and must take advantage of alternative learning platforms, such as online learning, open universities, and mobile apps (Boston Consulting Group 2016).

4.5 New business strategies and model

Industry 4.0 is hailed as the fourth industrial revolution after mechanisation (first), mass production (second) and automation (third) because it introduced the world to cyber physical systems (Lasi, et al., 2014). With the new revolution comes the need for new business strategies and models so that organisations can cope with the demands of their customers and can stay competitive. This has resulted in a gradual shift from conventional business models to the ones focussing on digitisation of factories so that smart environments can be created. Research (Burmeister, Lüttgens, and Piller, 2016) shows that organisations have not completely deserted the traditional business models but their sustainability has come into question and they are falling short while answering questions such as:

- Are the existing business models still economically sustainable and resilient?
- Can the organisation’s data be used more efficiently or be converted into a source of income?

These questions can be amalgamated into a single one:

- Is it possible to realize Industry 4.0 potential alone or is special value-added network with partners, customers or even competitors needed?

Main Features of the Industry 4.0	Main issues affecting traditional Business Model	Main requirements to face digital transformation
Interoperability	Networking and reduction of barriers	Standardisation
Virtualization	Flexibility and personalisation	Work organisation
Decentralization of decision making	Individualised mass production	Availability of products
Real-time capability	Local production	New Business Models
Service orientation	Low price	Know-how protections
Modularity	Smart goods and services	Availability of skilled workers
Big data analytics	Fragmentation of the value chain/ Globalisation and decentralisation of production	Research investment/ Professional development



According to Schmidt et al. (2016), large companies have the understanding, resources and skills to answer this question but SMEs have been struggling in their desire to digitise their manufacturing operations that incorporate all the nine technology trends of Industry 4.0 (as mentioned in section 3.1). This has created a huge problem for SMEs that want to stay competitive but are simply incapable of establishing key performance indicators that will help them assess their readiness for Industry 4.0 much less look forward towards return-on-investment and benefits realisation.

Ibarra, Ganzarain, and Igartua (2018) have concisely summarised the features, challenges and requirements related to Industry 4.0 business models as shown in the table below.

A published report suggests that Industry 4.0 could unlock about €500bn for UK if digitisation is taken on-board (The Guardian, 2017). These statistics clearly show the importance of manufacturing SMEs in the UK and for them digitisation is the next hurdle for which sound business strategies and models are required that can incorporate the nine technology trends of Industry 4.0. (as mentioned in section 3.1) SMEs should aim to go through a logical sequence of activities where they should first and foremost assess their readiness, followed by return-on-investment calculations and then benefits realisation. Depending on the individual needs of an SME, the pathway can be divided into categories (for example; infrastructure, proprietary software packages, people etc.). These categories can be assessed by answering focussed questions posed by the new readiness, return-on-investment and benefit realisation tools as shown in the following figure.

4.6 Upcoming technologies

The drivers behind Industry 4.0 originate in the digitization of product and service offerings, value chains and business models (PWC, 2017). We recognize three basic concepts (Flanders Make, 2017):

Cyber Physical Systems (CPS)

Physical systems with inherent partial intelligence provided by embedded software which:

- Gathers data via sensors and uses actuators to influence the system and its environment

- Analyses and stores the data
- Actively or reactively reacts with the real physical or virtual digital world, connected to each other via digital communication channels and within global networks

CPS is the connecting element in an Industry 4.0 environment.

Examples of technologies within CPS are smart sensors, cloud computing, artificial intelligence, and block chain.

Internet of things, services and people

Internet of things is the network of physical devices, vehicles, home appliances and other items (including people) embedded or equipped with electronics, software, actuators and connectivity which enables these physical items to connect and exchange data.

Within the industry, the IoT can realize the seamless integration of various manufacturing devices equipped with sensing, identification, processing, communication, actuation, and networking capabilities. Based on such a highly integrated smart cyber-physical space, it opens the door to create whole new business and market opportunities for manufacturing.

Examples of technologies within IoT are IoT platforms, smart sensors, big data and advanced algorithms.

Virtualization

Virtual modelling of product, machine, and production processes. This technology is used to design a product or process in a virtual (computer-) world before actually physically building the product or the manufacturing line. Virtual models are also used to train operators off line.

Examples of technologies within virtualization are augmented reality, virtual reality, mixed reality.



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Who is involved?



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Central Denmark Region



European Institute for Innovation
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