

Industry 4.0 – Opportunities and Challenges of the Industrial Internet

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A Industry 4.0 – Opportunities and Challenges of the Industrial Internet



The fourth industrial revolution – characterised by the increasing digitization and interconnection of products, value chains and business models – has arrived in the industrial sector. Our study, *Industry 4.0 – Opportunities and Challenges of the Industrial Internet*, is based on a survey of 235 German industrial companies and was conducted by the market research institution TNS Emnid. It presents the essential attributes, opportunities and challenges posed by this development. The surveyed companies belong to the manufacturing and engineering, automotive and process industries, as well as the electronics and electrical systems and information and communications industries.

The respondents expect that the digital transition will lead to a significant transformation of their companies that will require considerable investment. They estimate the share of investments in Industry 4.0 solutions will account for more than 50% of planned capital investments for the next five years. German industry will thus invest a total of €40 billion in Industry 4.0 every year by 2020. Applying the same investment level to the European industrial sector, the annual investments will be as high as €140 billion per annum.

The first significant driver for the advance of Industrial Internet solutions lies in the opportunity to integrate and better manage horizontal and vertical value chains. Companies surveyed expect more than 18% higher productivity over the next five years. While today only one fifth of the industrial companies have digitized their key processes along the value chain; in five years' time, 85% of companies will have implemented Industry 4.0 solutions in all important business divisions.

The digitization and interconnection of products and services (Internet of Things/Services) is a second important driver. It will contribute strongly to ensuring competitiveness and promises additional revenues of 2% to 3% per year on average. When applied to the German industrial landscape as a whole, additional revenues reach up to €30 billion per year. For the European industry sector, additional revenues amount to €110 billion annually.

A third major driver are the newly emerging, often disruptive, digital business models that offer significant additional value to customers through tailor-made solutions. These new business models are characterised by a considerable increase of horizontal cooperation across the value chains, as well as the integrated use and analysis of data. They are therefore capable of better fulfilling customer requirements.

The various opportunities, the large extent of change and the elevated need for investments make the Industrial Internet one of the most important topics for corporate management. However, the numerous challenges that the transition entails are also not to be underestimated. Besides the partly still unclear business cases for the Industrial Internet at company level, industry standards have to be defined and agreed upon and questions need to be answered, for example, in the area of data protection. The respondents also consider the required qualification of employees at increasingly digitized companies to be a major obstacle. Policy makers and industrial associations can provide significant support with these issues.

The fourth industrial revolution has begun and offers attractive opportunities for industrial companies. However, the Industrial Internet is not an end in itself. It is closely tied to clear economic objectives and holds the potential

for clearer differentiation in global competition. Our study is intended to help identify major opportunities and challenges and demonstrate solutions for successful implementation. The time to act is now!

Industry 4.0 – vision and mission at the same time

The essence of the Industry 4.0 vision, the “Internet of Things”, is the ubiquitous connection of people, things and machines. This connection is intended to produce a variety of new goods and services. Products, means of transport or tools are expected to “negotiate” within a virtual marketplace regarding which production elements could best accomplish the next production step. This would create a seamless link between the virtual world and the physical objects within the real world.

The sources of the major additional benefits of this vision for each respective case – and the resulting consequences – have yet to be defined. There are already extremely optimised production processes which are executed serially in a well-defined sequence. These production strategies will also be improved in the future and impede the introduction of new production approaches. The objective of Siemens is to allow its customers to be more competitive and to make every effort to

support them in developing further. In this respect, the continuous digitization of the value chain is essential for the industry’s future.

Examples of factories in which the production processes are digitally supported throughout already exist – however, these processes still have a low level of complexity. A “digital company” with a continuous digital value chain not only digitally integrates the shop floor, but also the development and sales departments from the office floor. Examples of this include the two Siemens electronics plants belonging to Siemens in Amberg and Chengdu.

Approximately 1,000 different products are manufactured in Amberg. In order to produce them in a flexible and efficient manner, the plant uses the latest software tools, such as NX and Teamcenter, Product Lifecycle Management (PLM) programmes, for production development, as well as a large number of SIMATIC controllers and SIMATIC IT, Manufacturing Execution System (MES) software, for production processes. These products work together seamlessly and are connected through interfaces with the

enterprise resource planning (ERP) systems. The use of these software tools has led to a significant increase in quality improvement (reduction from 550 to 12 defective steps out of a million process steps in total) over the past twenty years. Production volume has increased many times over the same period of time, while staff numbers have remained almost the same.

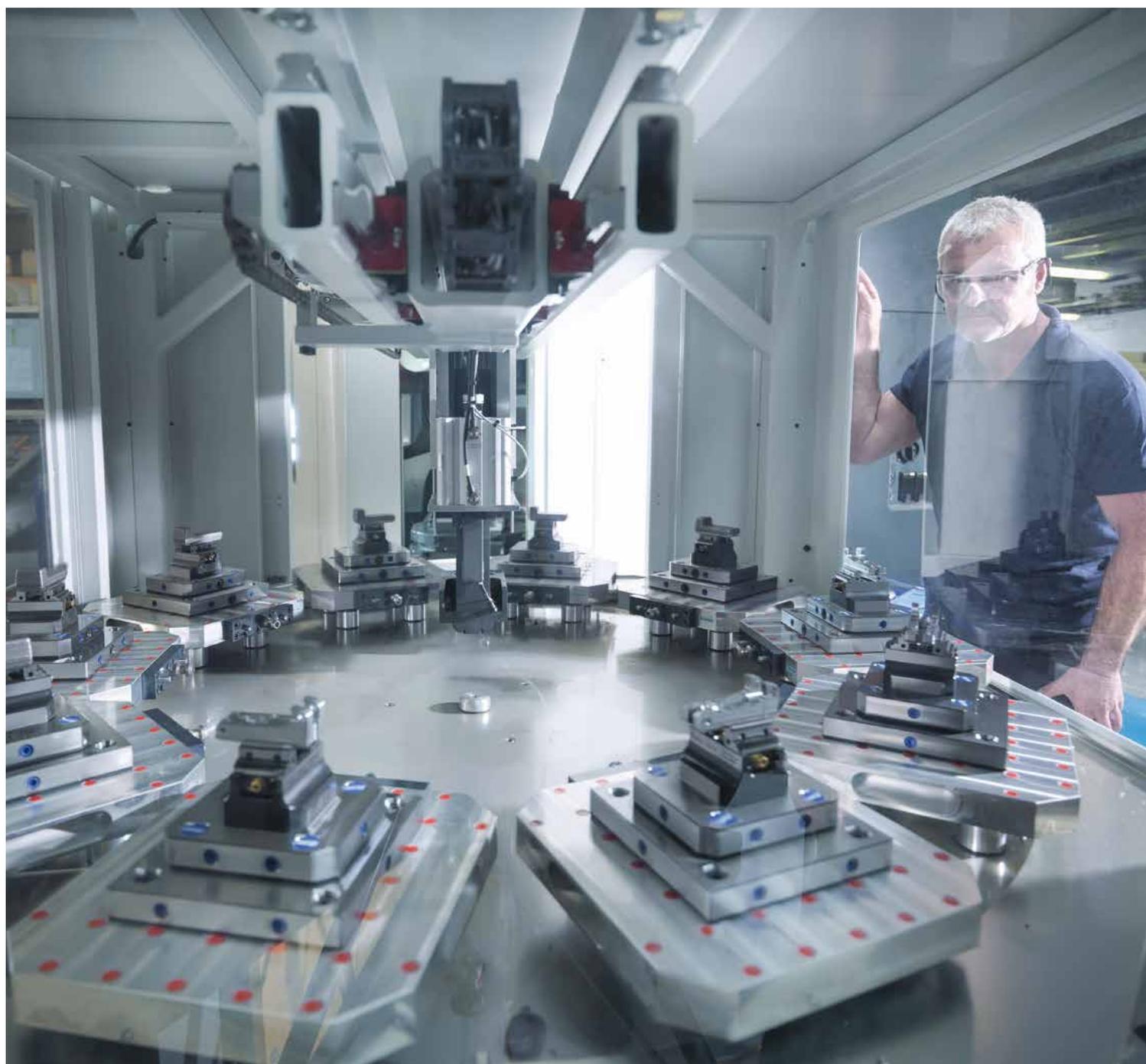
This study is intended to create awareness of the necessary path to digitization within the industry. Siemens products can support users in successfully embracing their upcoming transformation into a digital enterprise.



Prof Dr-Ing Dieter Wegener
Siemens AG, Digital Factory Division,
“Industry 4.0” Coordinator

translated from German

B Key findings of the survey



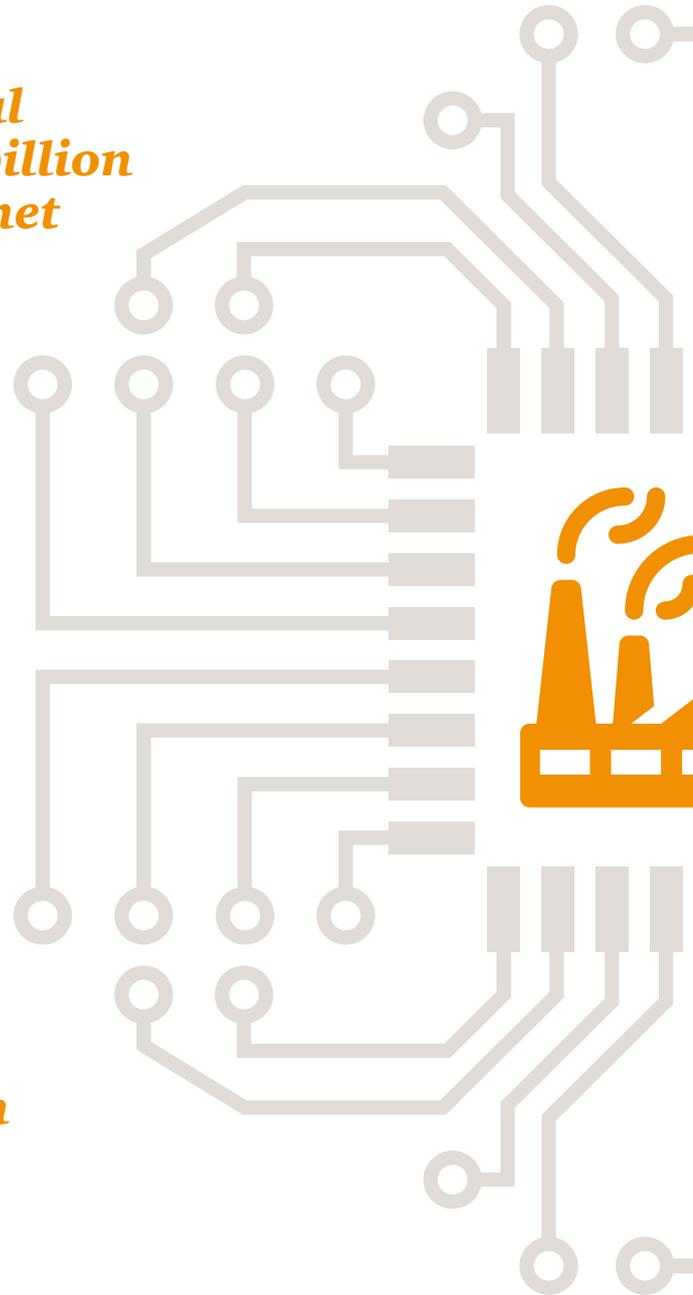
1 *The Industrial Internet transforms the entire company and must be part of the CEO agenda.*

2 *By 2020, European industrial companies will invest €140 billion annually in Industrial Internet applications.*

3 *In five years, more than 80% of companies will have digitized their value chain.*

4 *The Industrial Internet creates better productivity and resource efficiency – an 18% increase in efficiency within five years.*

5 *The integrated analysis and use of data are the key capabilities for the Industrial Internet.*



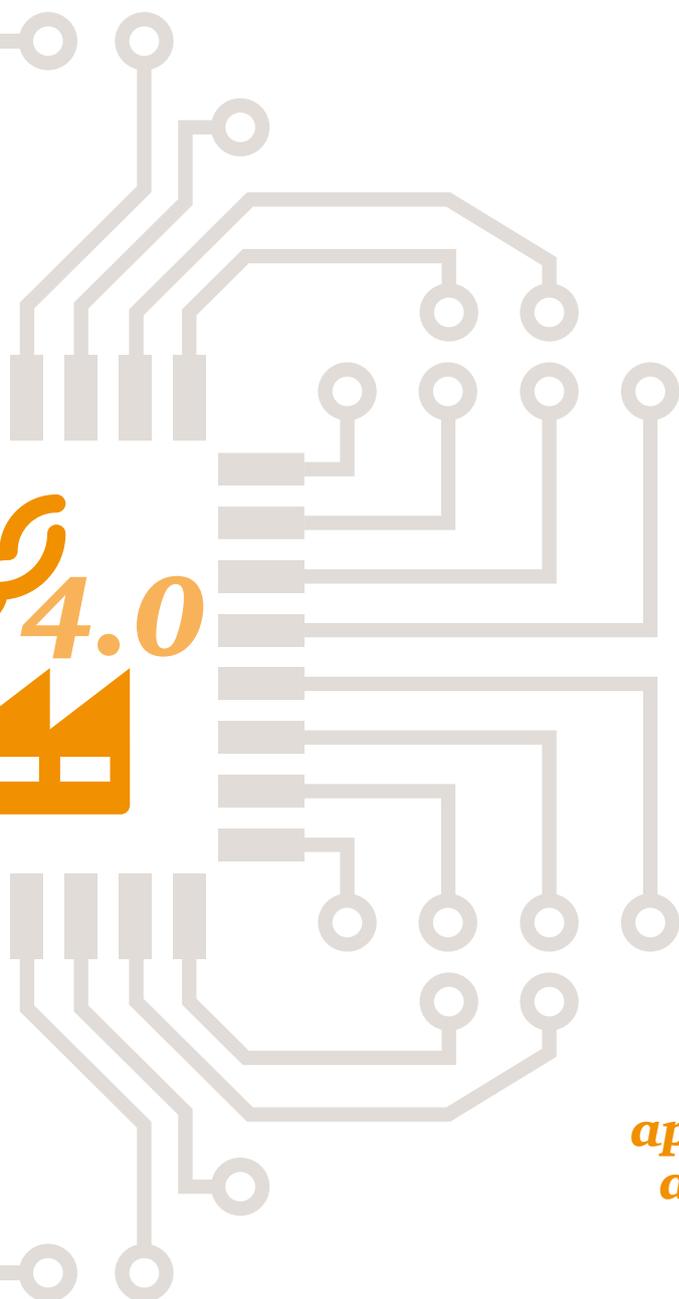
The Industrial Internet holds various challenges – policy-makers and industrial associations can help.

Horizontal co-operation allows for improved satisfaction of customer requirements.

The Industrial Internet paves the way for new, often disruptive digital business models.

Digitized products and services generate approximately €110 billion of additional revenues per year for the European industry.

Digitization of the product and service portfolio is the key to sustainable corporate success.



The results of the study are summarised in the following ten key findings:

1. The Industrial Internet transforms the entire company and must be part of the CEO agenda.

The Industrial Internet, also known as Industry 4.0, not only comprises the digitization of horizontal and vertical value chains but will also revolutionise the product and service portfolio of companies – with the ultimate goal of better satisfying customer needs. The potential uses of the Industrial Internet go far beyond the optimisation of production technologies. However, exploiting these opportunities requires considerable investment. The topic therefore inevitably occupies a leading position on the agenda of directors and managers of industrial companies.

2. By 2020, European industrial companies will invest €140 billion annually in Industrial Internet applications.

Over the next five years, the industrial companies surveyed will invest, on average, 3.3% of their annual revenues in Industrial Internet solutions. This is equivalent to nearly 50% of the planned new capital investments and an annual sum of more than €140 billion with regard to the European industrial landscape. These investments will have to be used along the entire value chain in order to achieve maximum success.

3. In five years, more than 80% of companies will have digitized their value chains.

One quarter of the companies surveyed have already achieved a high degree of digitization of their value chains. However, it is mostly only individual units and isolated applications that have been automated and digitized thus far. The companies expect that 86% of the horizontal and 80% of the vertical value chains will have a high degree of digitization by 2020 and will therefore be closely integrated.

4. The Industrial Internet increases productivity and resource efficiency – an 18% increase in efficiency within five years.

The industrial sector is required to produce ever larger quantities using fewer raw materials and less energy. The Industrial Internet allows higher productivity and resource efficiency and thus creates the conditions for sustainable and efficient production. The companies surveyed anticipate an average efficiency increase of 3.3% per year across all industry sectors due to the digitization of value chains. This amounts to a total of 18% in the next five years. They expect annual savings of 2.6% with respect to cost reduction.

5. The integrated analysis and use of data are the key capabilities for the Industrial Internet.

Already today the efficient analysis and use of data is of great significance for half of all companies surveyed. Moreover 90% of companies believe that the ability to analyse data will be decisive to their business model in five years. These companies primarily focus on the efficient exchange of data within their own value chain, the digital labelling of the products and the use of real time data to steer their production.

6. Digitization of the product and service portfolio is the key to sustainable corporate success.

Thirty percent of the companies surveyed have already digitized their products to a great extent and expanded their portfolio to include connected and automated services. A mechanically perfect product will no longer be enough to successfully withstand international competition. More than four out of five respondents – with the exception of the process industry – therefore expect that they will have achieved a high degree of digitization of their product and service portfolio within five years.

“Industry 4.0 will transform our entire value chain and allows us to develop innovative products and services. We must act now!”
CEO, manufacturer of processing machines

7. Digitized products and services generate approximately €110 billion of additional revenues per year for the European industry.

Companies which have already digitized their product portfolio to a great extent have grown above average in the past three years. Half of the companies surveyed anticipate double-digit growth in the next five years due to the intensified digitization of their product and service portfolio. One in five companies even expects sales to rise by more than 20%. In total, this amounts to an average, incremental sales increase of 2.5% per annum. Compared to all industrial companies in the five core industry sectors, this is equivalent to an annual sales potential of more than €30 billion for Germany and reaches up to €110 billion of additional revenues for the European industry in total.

8. The Industrial Internet paves the way for new, often disruptive digital business models.

The Industrial Internet will have a lasting effect on existing business models and will particularly also generate new, digital – often disruptive – business models. The focal point of this trend comprises increasing customer benefits through a growing range of value solutions (instead of products) and increased networking with customers and partners. The special quality of the digital change lies in the rapid acceleration of the speed of change. Disruptive innovations will also cause industry sectors like the information and communications industry to sustainably transform within a short period of time.

9. Horizontal co-operation allows for improved satisfaction of customer needs.

About half of all companies surveyed are already convinced that closer co-operation with value chain partners – combined with increased horizontal interconnection – is of great significance. The importance of this will further grow in the context of Industry 4.0 in light of increased digitization – particularly where new, digital business models have to be established. More than 80% of the companies surveyed believe that closer co-operation and a more vigorous horizontal connection of value chains will play an important role in five years.

10. The Industrial Internet holds various challenges – policy-makers and industrial associations can help.

Companies have to master several challenges on the way to becoming a Digital 4.0 champion. The main focus is on high investment levels and often unclear business cases for new Industrial Internet applications. Furthermore, sufficient skills to meet the needs of the digital world must be ensured. Binding standards must also be defined and tasks in the area of IT security have to be solved. Policy-makers and industrial associations can help with these latter challenges in particular, by advocating uniform industrial standards at a European or international level and promoting efficient rules for data security and data protection.

C Survey results in detail



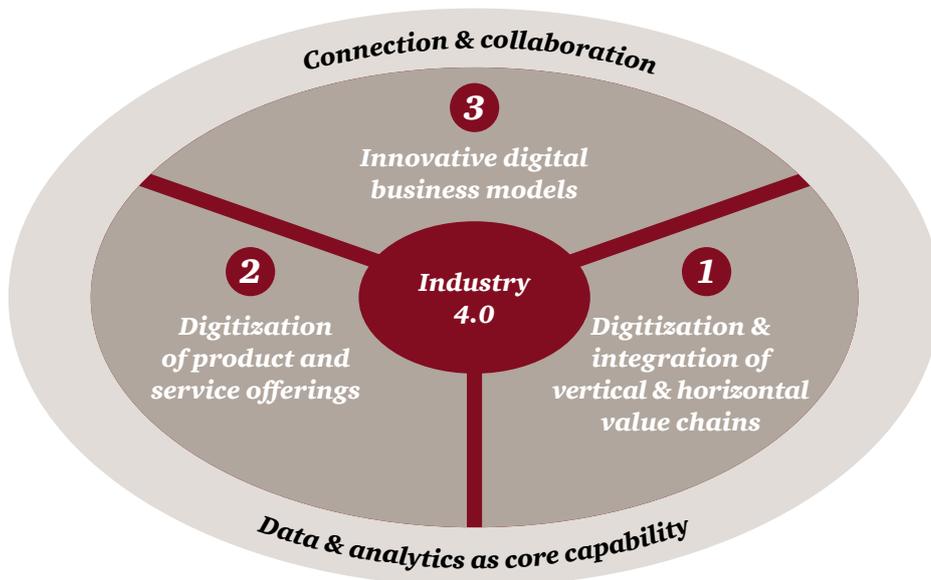
1 The Industrial Internet transforms the entire company and must be part of the CEO agenda.

The Industrial Internet, also known as Industry 4.0, not only comprises the digitization of horizontal and vertical value chains but will also revolutionise company product and service portfolios and lead to the implementation of new, often disruptive digital business models. The Industrial Internet promotes both the transformation of all important business processes and a realignment of

the product and service portfolios. The potential uses of the Industrial Internet thus go far beyond the optimisation of manufacturing techniques and its implementation also requires considerable investment. The issue is therefore taking a key position at the top of the agenda for CEO's, directors and managers at leading industrial companies.

Fig. 1 Industry 4.0 comprises the networking of value chains, the digitization of products and new business models

Framework for Industry 4.0



“Industry 4.0 means far more to us than just an end in itself. We associate it with clear economic aims and the opportunity for better differentiation in global competition.”
 Plant manager at Digital Factory, an electronics group

Our definition of the Industrial Internet or Industry 4.0 covers three aspects:

1. Digitization and increased integration of vertical and horizontal value chains

Leading industrial companies are digitizing and connecting functions along the vertical value chain – from the digital order process, customised product development and the automated transfer of product data to connected planning and manufacturing systems and further on to integrated customer service. Moreover, the horizontal integration of inventory and planning data is carried out with suppliers, customers and other value chain partners.

2. Digitization of product and service offerings

Digital champions expand their existing range of products with complete digital product descriptions as well as intelligent and connected solutions (“embedded systems”/“Internet of Things”). These include online connection for the regular matching of performance and wear data or the development of customised products with a lot size of 1. The service portfolio will be further extended by connected, automated or data-based services.

3. Introduction of innovative digital business models

The higher level of integration and the technological opportunities provided by the Industrial Internet will create new, digital business models. Integrated solutions or value-added services are characterised by significantly higher customer benefits and will revolutionise existing product portfolios and performance relationships. They are often the result of disruptive innovative processes. Integrated solutions offer new companies the opportunity to enter existing markets and established customer relationships since one effect of digitization is the reduction of traditional market entry barriers.

The basis of the Industrial Internet is the increased availability and integrated use of relevant data by connecting all products, resources and companies involved in the value chain. It includes the ability to generate additional value from available data and ultimately to maximise customer benefits. This requires a fundamental transformation of processes, the product and service portfolio as well as the existing business models. In sum, it is a comprehensive process of change which can only be successfully driven by top management.

Definition Industry 4.0

“The term Industry 4.0 stands for the fourth industrial revolution. Best understood as a new level of organisation and control over the entire value chain of the life cycle of products, it is geared towards increasingly individualised customer requirements. This cycle begins at the product idea, covers the order placement and extends through to development and manufacturing, all the way to the product delivery for the end customer, and concludes with recycling, encompassing all resultant services.

The basis for the fourth industrial revolution is the availability of all relevant information in real time by connecting all instances involved in the value chain. The ability to derive the optimal value-added flow at any time from the data is also vital. The connection of people, things and systems creates dynamic, self-organising, real-time optimised value-added connections within and across companies. These can be optimised according to different criteria such as costs, availability and consumption of resources.”

Source: Platform Industry 4.0 (translated from German).

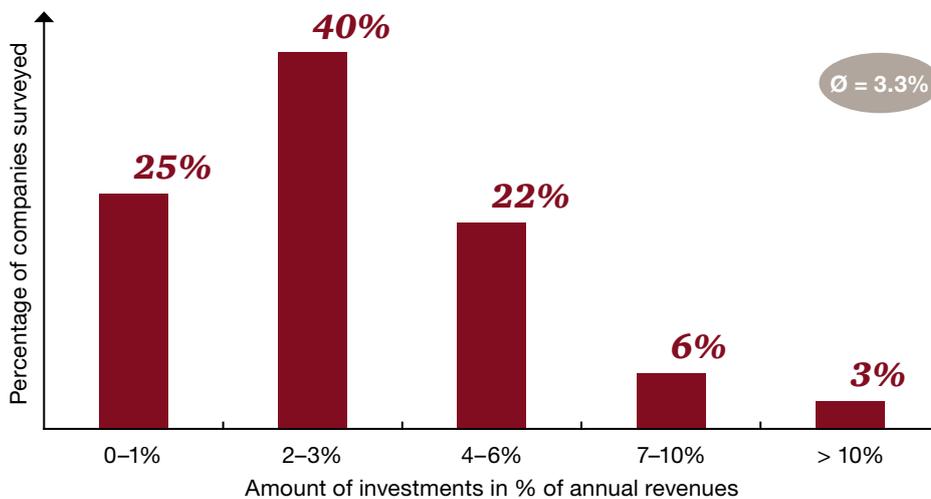
2 By 2020, European industrial companies will invest €140 billion annually in Industrial Internet applications.

Over the next five years, the 235 industrial companies surveyed will invest on average 3.3% of their annual revenues in Industrial Internet solutions. This is equivalent to nearly 50% of the

planned new capital investments and an annual sum of more than €140 billion with regard to the European industrial landscape.

Fig. 2 In the next five years, the companies will invest 3.3% of their annual revenues in Industry 4.0 solutions

Average annual investments in Industry 4.0 applications



Note: 4% of the companies surveyed provided no information on the amount of their investments.

Only a quarter of the companies have not yet considered it necessary to channel significant investments into Industrial Internet applications. By contrast, one third of the respondents will take on opportunities to increase efficiency and ensure competitiveness as the most important investment challenge. These companies will invest on average 7% – a major part of the budget – in Industry 4.0 applications (this is equivalent to the average of the top three categories with investments $\geq 4\%$).

Industrial Internet solutions enable efficiency improvements and reduce costs along the entire value chain. The study's participants therefore place an equally high priority on investments in the entire supply chain, the digitization of product development and engineering, as well as in the automation of manufacturing. It is only investments in the digitization of sales that are rated slightly lower. Investments cover the entire range, from connections between operation materials, machines and logistics systems in the form of cyber-physical systems (CPS), through solutions of sensor technology to the exchange of data controlled in real time along the value chain.

Fig. 3 Investments in Industry 4.0 solutions are spread over all key areas along the value chain

Industry 4.0 investments broken down by steps of the value chain

Extrapolating the planned investments of the companies surveyed to the five industry sectors represented in the study results in an annual investment of €140 billion by European industry. The two industry sectors that will make above average investments in digital enterprise solutions are the information and communications (3.9% per annum) and manufacturing and engineering industries (3.5% per annum).

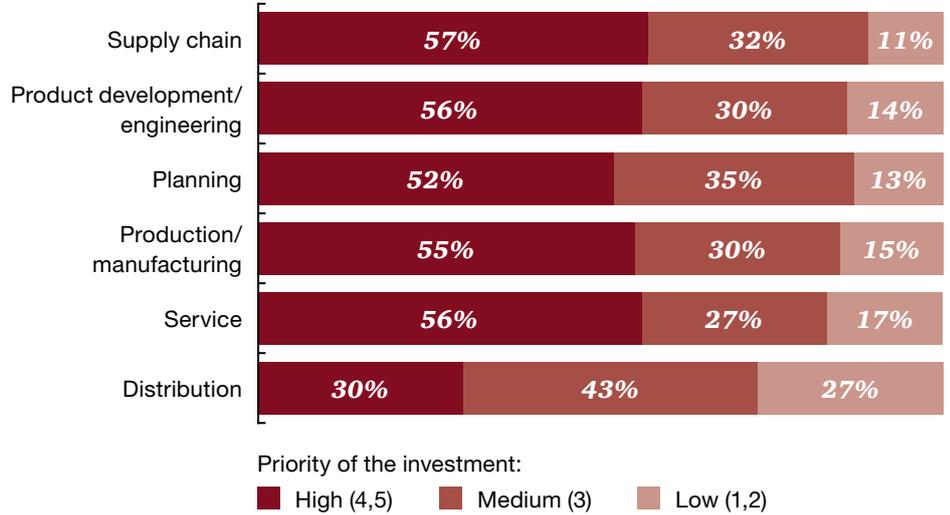
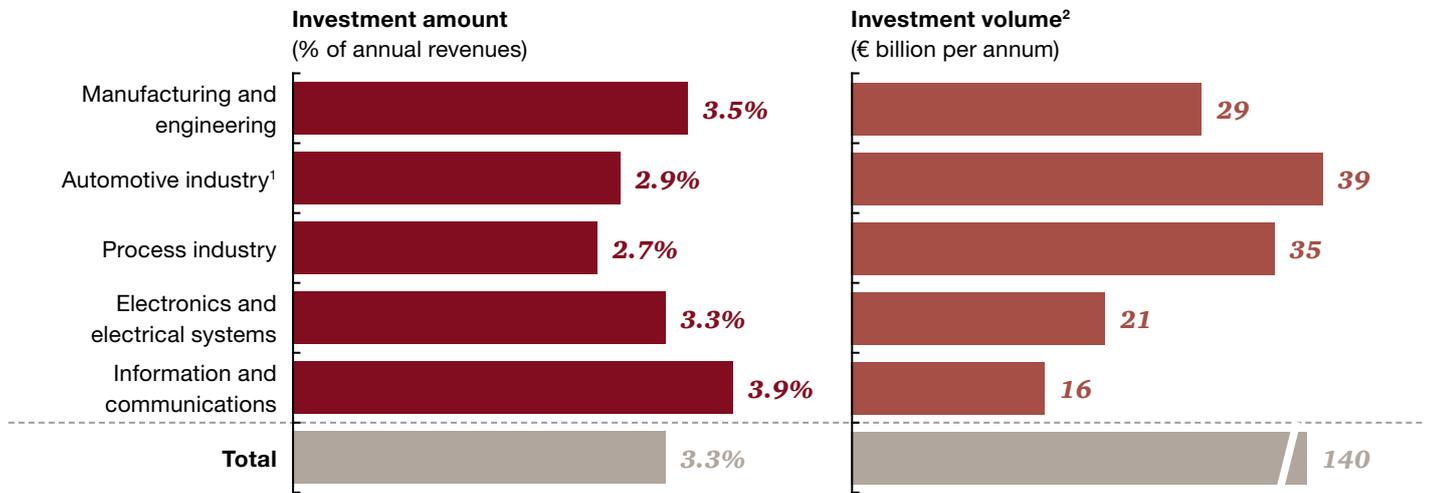


Fig. 4 The European industry will invest €140 billion annually in Industry 4.0 solutions until 2020

Annual investments in Industry 4.0 solutions through until 2020



¹ Projection for the entire automotive industry (economic sector 29: production of motor vehicles and motor vehicle parts).
² Projection on the basis of total revenues per industry sector in the EU-28.

Companies from the information and communications industry mainly focus their investments on products and services for flexible real time manufacturing planning and control. This sector also places importance on the optimisation of the logistics systems. Companies in the machine building industry, meanwhile, concentrate

their investments in manufacturing automation, recording real time data along the supply chain as well as on the expansion of manufacturing execution systems (MES). Planned investments by the process industry in Industrial Internet applications still lag behind those in the other industry sectors.

Overall, industrial companies across all industry sectors have realised that they can only meet increasing customer requirements with significant investments in Industry 4.0 solutions. This is the only way for them to remain competitive and to improve their own competitiveness on a long-term basis.

3 In five years, more than 80% of companies will have digitized their value chain.

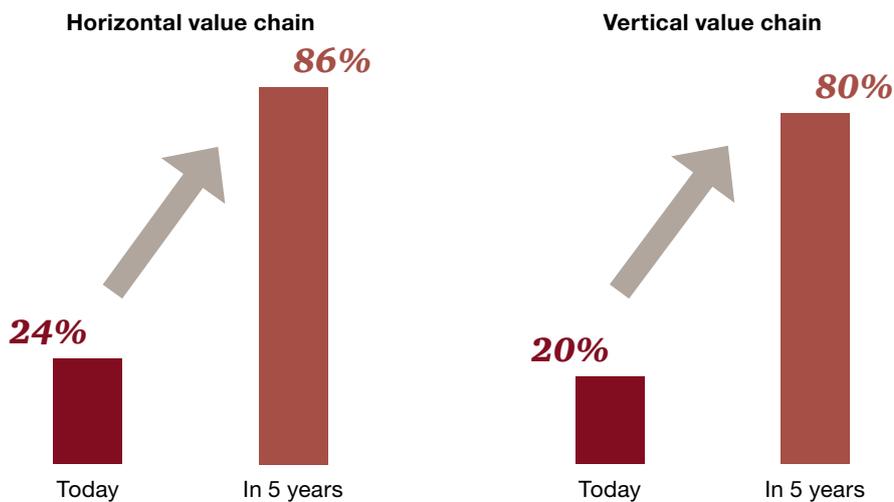
The Industrial Internet has now been added to the agenda of the majority of companies. Two-thirds of the companies surveyed are already actively working on digitizing and further connecting their value chains. One fourth of the respondents already classifies the

current degree of digitization of their value chain as high. In concrete terms, this means that most of the companies are already using or have implemented Industrial Internet solutions in various divisions.

Fig. 5 The already considerable degree of digitization will increase with Industry 4.0 in the next years

Degree of digitization of the value chain

Share of companies with a high degree of digitization (4,5)



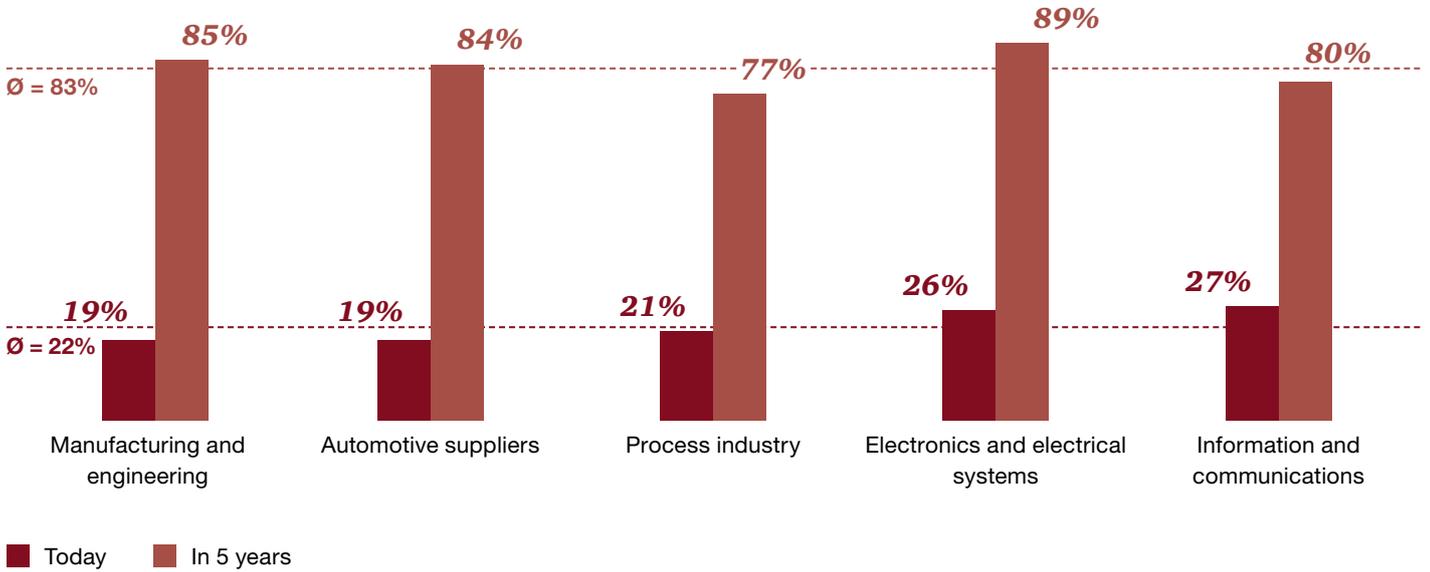
The study shows that the level of digitization of the value chains will rise rapidly in the future. It is estimated that 86% of the horizontal and 80% of the vertical value chains will be highly digitized in five years. This kind of conscious investing in further digitization opportunities can be seen across all industry sectors.

The Industrial Internet and the digitization of value chains are important prerequisites for all companies, irrespective of their size. They are necessary in order to maintain competitiveness and avoid falling behind the increasingly faster pace of development across industry sectors.

Fig. 6 The digitization of value chains will significantly increase across all industry sectors

Degree of digitization of the value chain by industry sector¹

Proportion of companies with a high degree of digitization (4,5)

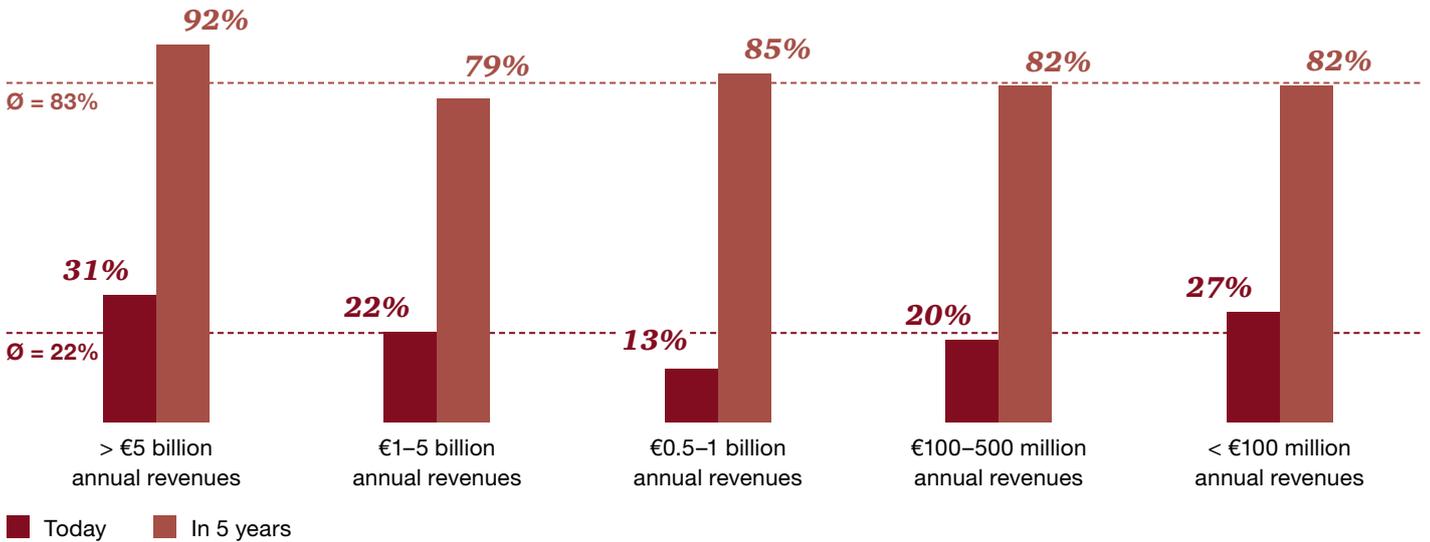


¹ Horizontal and vertical value chain.

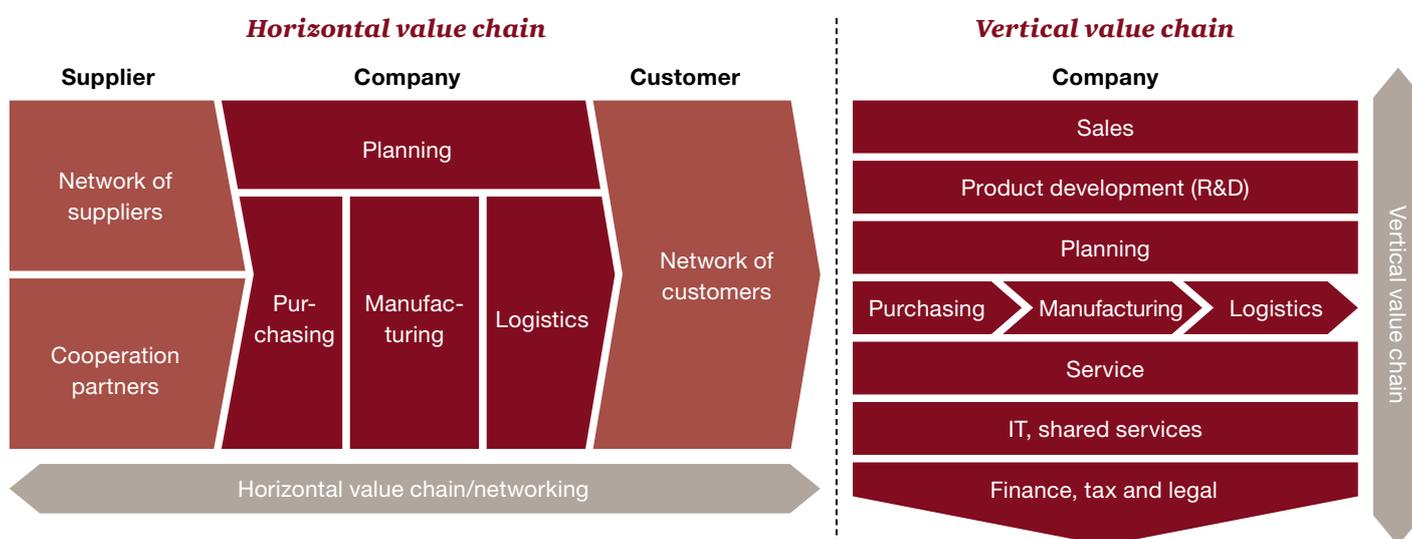
Fig. 7 The digitization of value chains has top priority for all companies irrespective of size

Degree of digitization of the value chain according to the size of the company¹

Proportion of companies with a high degree of digitization (4,5)



¹ Horizontal and vertical value chain.

Fig. 8 Industry 4.0 requires comprehensive digitization of the horizontal and vertical value chains

Digitization is finding its way into horizontal as well as vertical value chains to an equal extent. The digitization of the horizontal value chain integrates and optimises the flow of information and goods from the customer through their own company to the supplier and back. This process involves the integration and proactive controlling of all company internal departments (eg, purchasing, manufacturing, logistics and planning). It also includes all the external value chain partners that are needed to satisfy customer requirements and fulfil requested services.

Vertical digitization, on the other hand, is associated with securing a consistent flow of information and data from Sales through Product development to Manufacturing and Logistics. Quality and flexibility can be increased and costs reduced by means of optimal

connection of manufacturing systems, the prevention of system failures and better analytical abilities.

For example, a leading manufacturer of electronics components has already achieved a very advanced level of digitization in some plants. This was realised by implementing various processes and value chain optimisations, including:

- Vertical availability and integration of all development, manufacturing and supply chain data
- Effective data management and improved data analysis in real time
- Individual IP addresses for all components and systems in the plant
- Automation of all important process steps in a one-piece flow
- Continuous measurement and optimisation of all process steps and parameters

This produced notable increases in performance at the plant level and significantly reduced the error rate in manufacturing.

The majority of the companies identified a clear added value in the digitization of the value chain. Industry 4.0 or the Industrial Internet is more than just hype. It will become reality in most of the industrial companies in the next five years.

“We already today require extensive data and maximum transparency from our suppliers for seamless quality monitoring along the value chain.”
 Vice President, manufacturer of automation technology

4

4 The Industrial Internet creates higher manufacturing and resource efficiency – an 18% increase in efficiency within five years.

The fourth industrial revolution plays an important role in making long-term manufacturing efficiency possible. The industrial sector is required to produce ever larger quantities using fewer raw materials and less energy. Industry 4.0 will help companies create efficient manufacturing processes with increased production, energy and resource efficiency.

Over the next five years, the companies surveyed expect a noticeable quantitative benefit from the planned investment in Industrial Internet applications. They anticipate an average efficiency increase of 18% through digitized enterprises across all industry sectors. This is equivalent to an annual efficiency increase of 3.3%. In fact, more than one third of the companies actually see even greater potential.

Many improvements may result from the digitization of processes and value chains, for example:

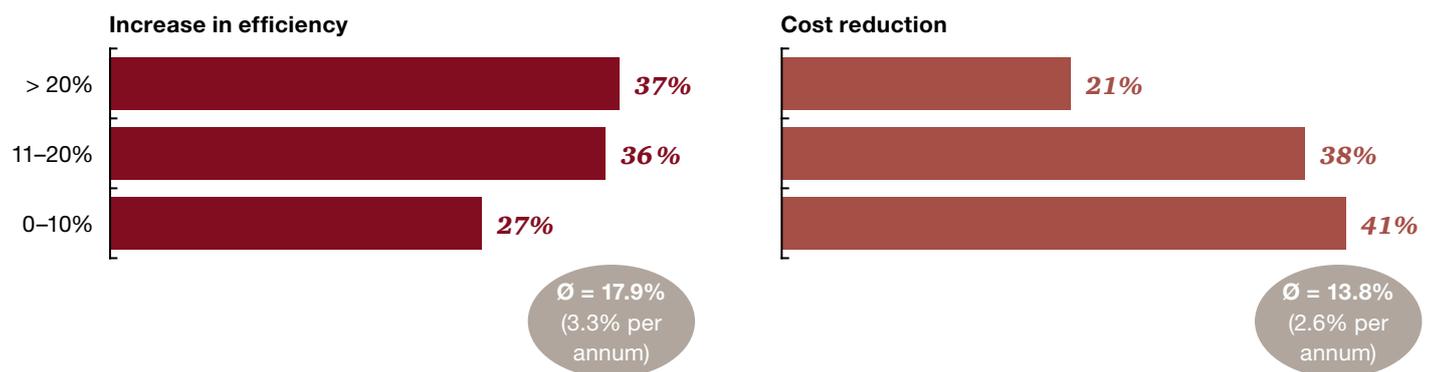
- Focussing on core areas in the individual value chain
- Reduction of redundancies in processes
- Minimising quality losses
- Making processes more flexible and coherent

In concrete terms, increased transparency improves the utilisation of machines and systems (eg, by optimising lot sizes). Digitization and greater connectivity in process organisation may permit areas of work to be rationalised and may yield gains in productivity. The intelligent analysis and integrated use of data for controlling purposes also reduces the rejection rate in production.

Fig. 9 Expectations concerning the benefit of Industry 4.0 solutions are high – especially with regard to increases in efficiency

Expected quantitative benefit of Industry 4.0 applications

Cumulative effect in 5 years (in relation to today)/Share of respondents



“Besides improvements in efficiency and cost savings, Industry 4.0 also makes it possible to save important resources.”
Head of Production, machine tool manufacturer

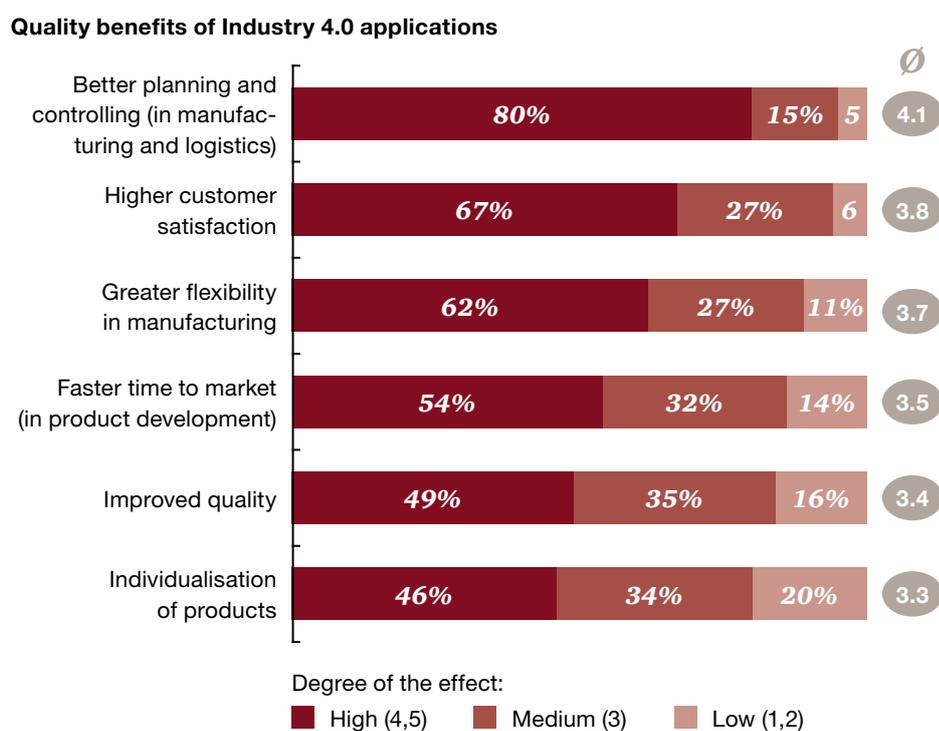
When asked about cost reduction, the surveyed companies anticipate Industry 4.0 to yield additional annual savings in the amount of 2.6% on top of the usual cost savings. The expectations of the process industry for a cost reduction of 1.9% per year are considerably more conservative than those of the discrete manufacturing industries.

Expected cost savings not only apply to intra-company increases of efficiency but are also the result of an increased horizontal integration. A reduction of production costs in the amount of 2.6% per year can only be achieved if all partners along the entire supply chain are also able to achieve individual cost reductions and pass them on. Measured against the cost reductions typical for industrial companies of 3% to 5% per annum, the planned savings due to the Industrial Internet will make a decisive contribution to the sustainable increase of competitiveness of German companies.

Far-reaching qualitative benefits are expected in addition to a measurable, quantitative benefit. The companies surveyed have very high expectations with regard to better planning and control in manufacturing or in logistics. In addition, they expect Industry 4.0 to provide higher customer satisfaction and greater flexibility in manufacturing.

Better planning and control are closely connected with the integration of horizontal value chains across

Fig. 10 Companies expect far-reaching quality benefits of Industry 4.0 and higher customer satisfaction



companies and represent important requirements for planned efficiency increases. By contrast, increased vertical integration allows for greater flexibility of manufacturing and a reduction of the time to market.

The Industrial Internet also offers the opportunity to satisfy the requirements of customers in terms of traceability of material, product and process data. Many companies, for example, in the

automotive or electronics industry, move quality control further upstream in the value chain. They expect full information from their suppliers in order to monitor the entire life cycle of a product. Only when taking all traceability data into account, increasing the use of sensors and actuators in manufacturing and collecting all – instead of only select – data (big data), the constantly rising requirements can be fulfilled without disregarding profitability.

5

5 The integrated analysis and use of data are the key capabilities of the Industrial Internet.

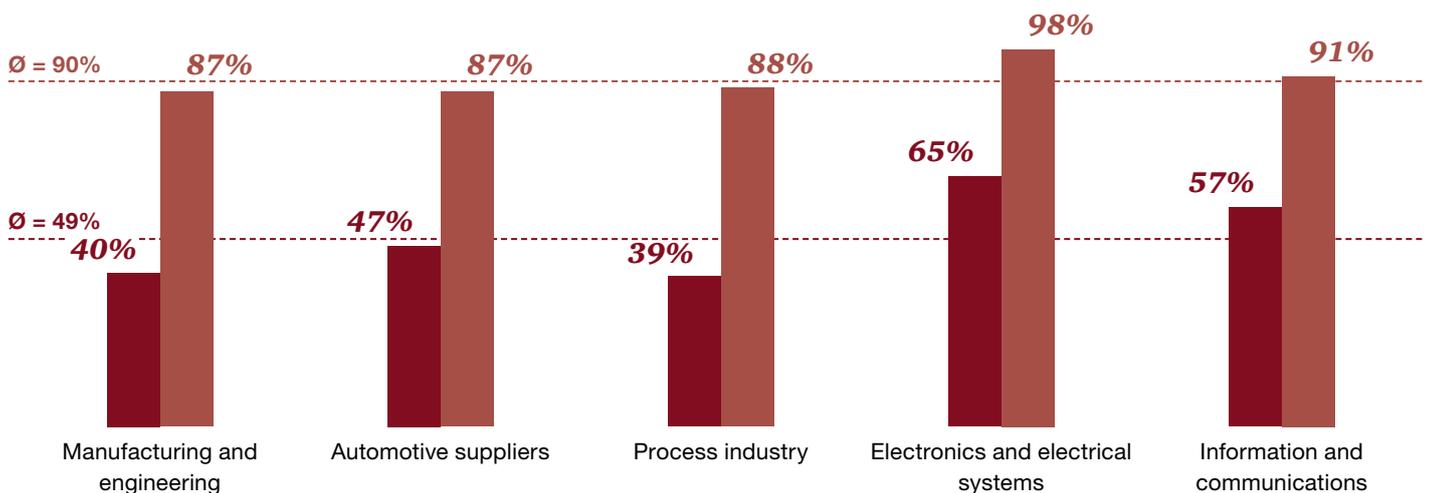
The analysis and use of data play a major role in the Industrial Internet. The rapidly growing number of sensors, embedded systems and connected devices (“Internet of Things”) as well as the increasing horizontal and vertical networking of value chains result in a huge continuous data flow. While these gigantic amounts of data are collected along the entire value chain, they have in many cases not been used in a structured and sufficient manner.

The analysis and use of data are already highly important for half of all companies surveyed. The electrical engineering and electronics industry places a particular emphasis on this capability due to the data intensity of the products and solutions in the sector. Ninety percent of the companies from all five industry sectors are convinced that the ability to efficiently analyse and effectively use large data volumes will be of vital importance for the future success of their business model. This evaluation also applies to those industries in which the analysis and use of data are not yet a top priority.

“We are sitting on a pile of data today – but we are not able to use the data in an integrated and structured way for the optimal control of production.”
Head of Production, machine tool manufacturer

Fig. 11 The importance of data varies depending on the industry sector, but overall it is increasing significantly

Importance of the analysis and use of data for the business model
Proportion of companies with a great importance of data (4,5)



The integrated analysis of data makes it possible, among other aspects, to examine processes in an integrated manner and to optimise them on the basis of the findings made. An automotive supplier provides an example of the use of modern data and analysis procedures in manufacturing. In order to further increase the quality and reliability of the delivered products, a big data solution was recently implemented which connects and processes huge amounts of different sensor data on the basis of complex analyses (800 billion entries, or 50 terabyte data per year when fully configured). In doing so, defective parts can be identified and disqualified early in the manufacturing process. Furthermore, increased transparency improves the decision-making basis for

each company and lowers redundancies within the entire supply chain. This can lead to considerable increases of efficiency and thus to clear competitive advantages.

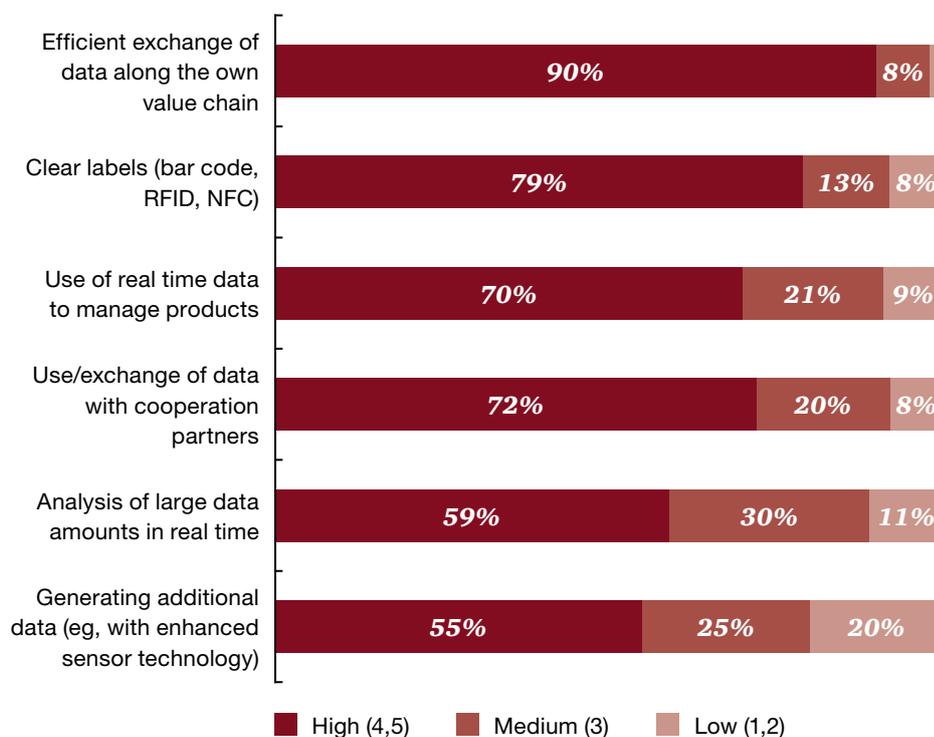
In addition, the analysis and use of data are decisive requirements for the development of new, digital business models, the optimisation of customer interaction as well as the increase of a company's profitability. A large company from the process industry provides a relevant example. In order to maximise profitability, a highly complex optimisation problem must be solved continuously. Current demand, availability of machines, current raw material prices and other process parameters are taken into account to decide which products are to be

manufactured in which lot sizes. A big data solution accelerates the highly complex simulation calculations required for this by a factor of 50 and helps to achieve a considerable increase of profitability.

Today, the companies' focus is primarily on the safeguarding of an efficient exchange of data within the own value chain, the clear labelling of products (eg, with a bar code, RFID or NFC) as well as on the use of real time data to control the production. Although many companies already have large quantities of data, they cannot use them in an integrated manner or access them at company level. The companies surveyed only mentioned the use and exchange of data with cooperation partners in fourth place.

Fig. 12 The efficient exchange of data along the own value chain becomes particularly important

Significance of data and analysis competences in the context of Industry 4.0



Industry 4.0: Existing data open up new opportunities

The market for Industry 4.0 applications is on the path from vision to reality. Evidence of this could clearly be found at Hanover Fair 2014, the leading trade fair of the industry. Industry 4.0 is extremely important for industrial Germany because the manufacturing industry remains a decisive factor for our strong position in the world economy. Various action plans from the German federal government and concerted initiatives by industrial associations and commercial companies like Platform Industry 4.0 underpin the innovative and productivity potential which we all see in connection with Industry 4.0.

From the perspective of Bosch and its customers, we emphasize the great significance of Industry 4.0 applications for the entire industry of producing companies, including logistics departments. Bosch is the leading supplier in this market, for example, for industrial controlling and process technology. Moreover, it is also the leading consumer of Industry 4.0 applications with more than 260 manufacturing plants worldwide. We can already offer innovative and tested solutions to our customers which were developed by our plants as and tested and optimised under real conditions. Our customers thus profit from the manufacturing experience of Bosch.

We expect that Industry 4.0 applications will provide German industrial companies with a high level of diverse opportunities. Particularly in the case of the middle market, Industry 4.0

provides the opportunity to stand out with new services – or to establish closer ties with customers (in the case of B2B) through data services across supply chains like inventory tracking. Of course, such opportunities also entail challenges. This requires the development of additional competences, particularly in IT areas like data security. It will be crucial for small and medium-sized companies to have appropriate partners with the necessary expertise at their side. They must also make use of new services and supply models like software as a service (SaaS).

The potential benefits are diverse and directly depend on the application case. The collection and visualisation of existing process and machine data from the different levels of the automation pyramid help to create new data transparency. This provides an important impetus for the continuous improvement process in manufacturing. In addition, analysis algorithms and refined policies for large data volumes help to selectively realise applications that are tailored to the respective needs of the end customers. These range from the continuous analysis of process data for the purpose of reducing scrap and rework, through the monitoring of machine cycle times (specifically at the bottleneck) to maximise the output, on to predictive maintenance for a selective planning of maintenance activities and minimisation of down time. All of this is possible. Finally, we must also focus on automation. Both simple and complex business processes can be initiated and monitored with the new applications: from simple notifications by e-mail, text message or app to automatically initiated ordering of spare parts and monitoring of maintenance orders.

In the context of Industry 4.0 it is essential to develop solutions in close collaboration with the users. The Bosch Group has been doing this with different users in the automotive, industry and consumables production for many years.

In the future, we see the need for investments mainly in the field of data intelligence, i.e., for derivations of profitable activities from the analysis of available data. We are talking about general and also far-reaching IT questions such as the connection and provision of data in the requested format. This also includes the use of control technology and specific software architecture expertise, for example, in security architectures in the context of remote access. These aspects are becoming ever more important for manufacturing, but they should certainly not be a core competence of a manufacturing unit in the future either.

The great potential of Industry 4.0 lies in data and particularly in the efficient use of newly gained opportunities.



Dr Daniel Hug

Bosch Software Innovations GmbH,
Head of Vertical Industry & Logistics

translated from German

6

6 Digitization of the product and service portfolio is the key to sustainable future success.

Industry 4.0 goes far beyond digitizing processes and value chains – this change also leads to a higher level of digitization in the product and service portfolio. A mechanically perfect product will no longer be enough to successfully compete on a global scale. The differentiation of products is moving increasingly in the direction of software as well as superior sensor technology, connectivity and generation of data.

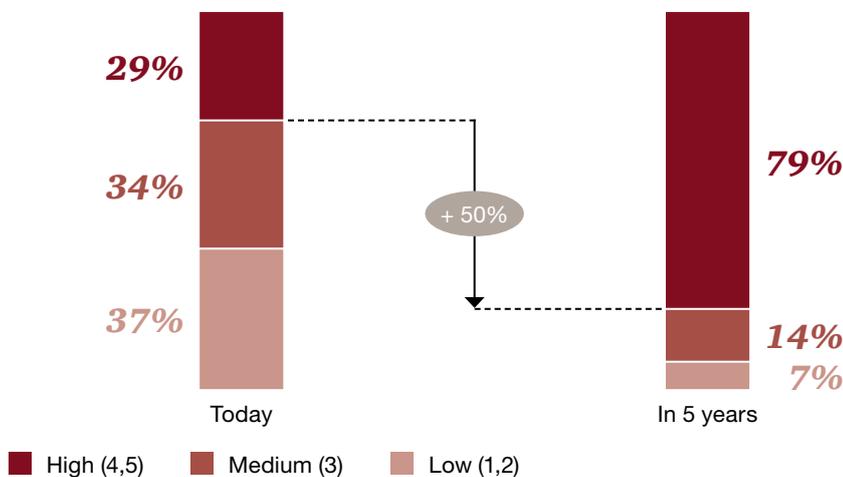
Products that are primarily mechanical today will be enriched by digital solutions and connectivity. This process will create greater customer benefits. Besides the direct integration of digital “intelligence” into the products itself, benefits may also be considerably

increased by Internet-based services related to the product. For instance, the Industrial Internet provides the basis for the manufacturing of customised products at a competitive cost level (key word: lot size one).

Examples of digitized products can be found in all industry sectors. In the automotive industry, for example, customary brake systems have been turned into modern anti-block systems with the help of electronic control units. In manufacturing and engineering, the use and connection of appropriate sensors allow optimal, preventive maintenance of machines and systems, and ensure much more efficient operational management.

Fig. 13 The share of digitized products and services is rising significantly

Level of product portfolio digitization



The results of the study clearly show that digitizing the product portfolio is a widespread practice and will progress in coming years. At present, 29% of the companies surveyed already have a high percentage of digitized products. These companies have recognised the signs of the times and have expanded their portfolio to include connected, automated services. In this context, the level of product portfolio digitization does not depend on a company’s size at all. Many small and medium-sized companies are already focusing on digitized products in order to stand out in the market.

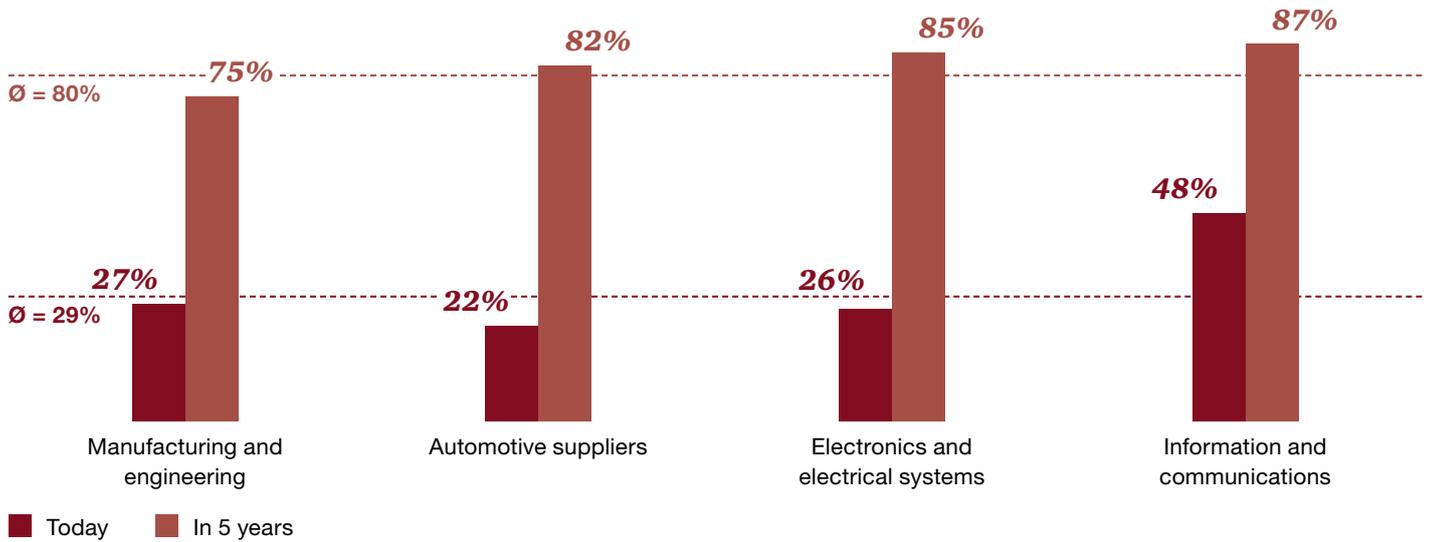
“Digitization paves the way for new product ideas which could previously not be realised in the same manner. For example, manufacturing data can be stored in the cloud, where it is analysed by experts in order to identify improvement potential.”
 Plant manager, manufacturer of automation technology

The digitization level of products will rise substantially in the coming years. By 2020, 80% of the companies surveyed will have achieved a high degree of digitization of their products and services. The proportion of companies with a highly digitized product portfolio will increase by more than five times, from currently 7% to 40%. Each company needing to succeed internationally will have to face this challenge.

The digitization of products is a phenomenon common across all industry sectors. In sectors like the information and communications industry the percentage of digitized products is of course already high. In the processing industry, the proportion of companies with a high level of digitization is currently only between 22% to 27%, depending on the industry sector. However, the general trend is the same for all sectors: The share of digitized products must and will increase substantially in the coming years.

Fig. 14 Product portfolio digitization has room for growth in the manufacturing sector

Level of product portfolio digitization by sector
 Proportion of companies with a high degree of digitization (4,5)



7 Digitized products and services generate approximately €110 billion of additional revenues per year for the European industry.

The importance or the share of software and digital elements in the total added value of a product – and thus naturally in company revenues as well – will increase considerably. The digitization of the product and service portfolio therefore serves the purpose of securing market share and keeping pace with international competition. What is more, companies also associate Industry 4.0 applications with clear growth targets.

The study shows that about 50% of companies surveyed expect double-digit growth in revenues in the next five years solely due to Industry 4.0 and increased product portfolio digitization. Eighteen percent of them even anticipate an increase in revenues of more than 20%. All in all, this results in an expected increase in revenues of 12.5% cumulated over five years. This figure is equivalent to additional growth in revenues of 2.5% per year.

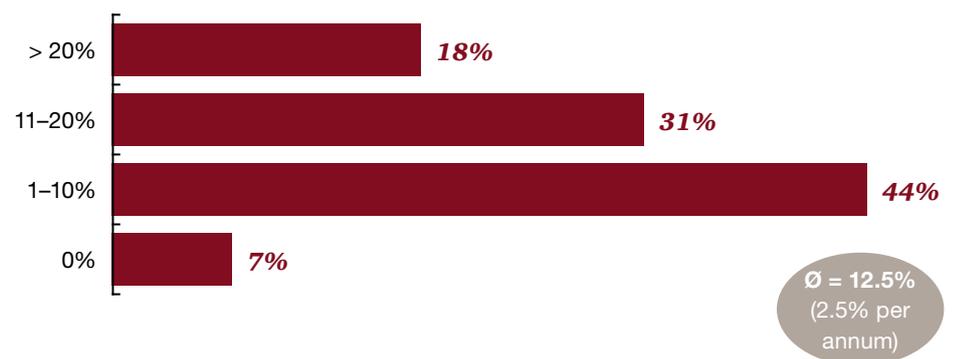
These are very ambitious growth targets for many companies. Interestingly, our survey shows that the expectations of SME's do not differ from the estimate of large groups.

Moreover, the results of the study reveal that companies with a more digitized product portfolio have already experienced above average growth in recent years. Nearly 70% of all companies with highly digitized products have achieved growth of more than 6% to 10% per year in the last three years, many of them even more than 10%. It must also be expected that this trend will gain additional momentum going forward. By contrast, half of the companies with a medium level of digitization have only achieved an increase in revenues of 5% per year or less.

Fig. 15 Companies expect a considerable increase in revenue attributable to Industry 4.0 solutions and digitized products

Expected increase in revenue attributable to Industry 4.0

Cumulated, incremental growth in 5 years



“*Future growth in sales will come from the services sector. The share in sales of digitized products and services will increase substantially.*”
Head of Production, company for measurement technology

The companies surveyed expect considerable growth in revenue across all industry sectors thanks to Industrial Internet solutions. The anticipated increase in revenue of manufacturing and engineering, automotive suppliers, the electronics industry and the information and communications industry amount to 13% to 14%. Only the process industry has much more moderate revenue expectations at around 8%, cumulated over five years.

Viewed across all industry segments, this shows significant potential for gains in revenue. Additional annual revenues of more than €110 billion can be expected in coming years by Industry 4.0 solutions in Europe alone. This is equivalent to additional revenues of €550 billion over five years. The Industrial Internet or Industry 4.0 will thus make a considerable contribution to growth in Europe in the next years.

Fig. 16 Companies with a strongly digitized product portfolio experienced faster growth

Growth in revenue depending on the level of digitization

Annual growth in the last 3 years

Level of product portfolio digitization

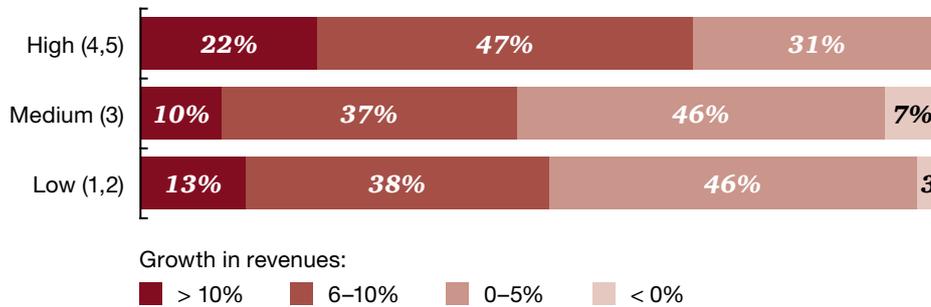
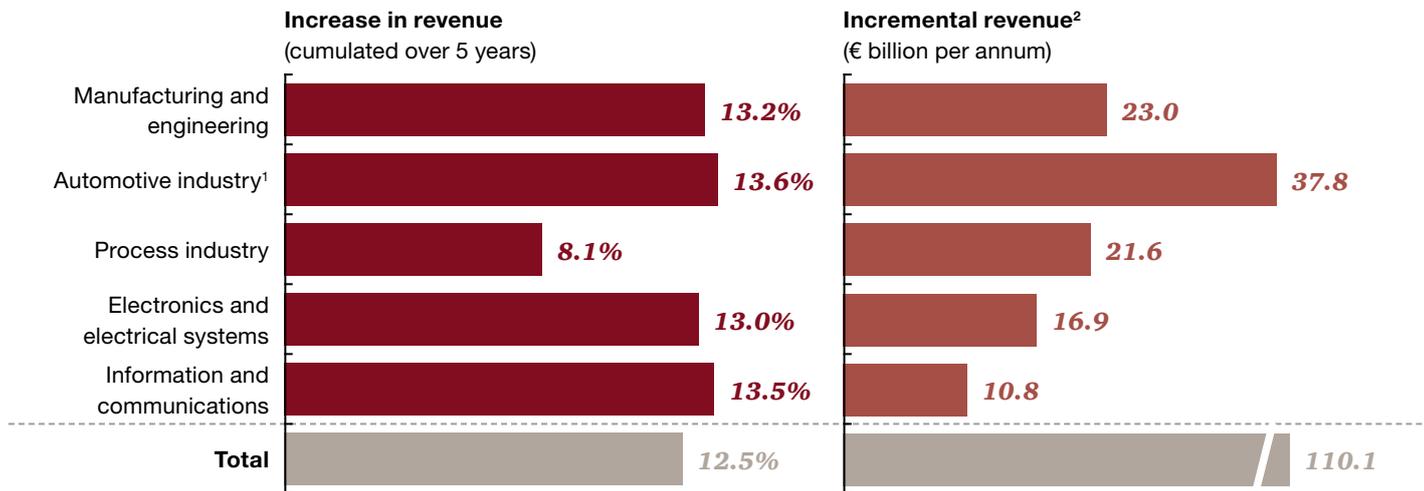


Fig. 17 European companies expect more than €110 billion additional revenue per year attributable to Industry 4.0

Growth in revenue attributable to Industry 4.0 per industry sector



¹ Projection for the entire automotive industry (economic sector 29: production of motor vehicles and motor vehicle parts).

² Projection on the basis of total revenue per industry sector in Europe.

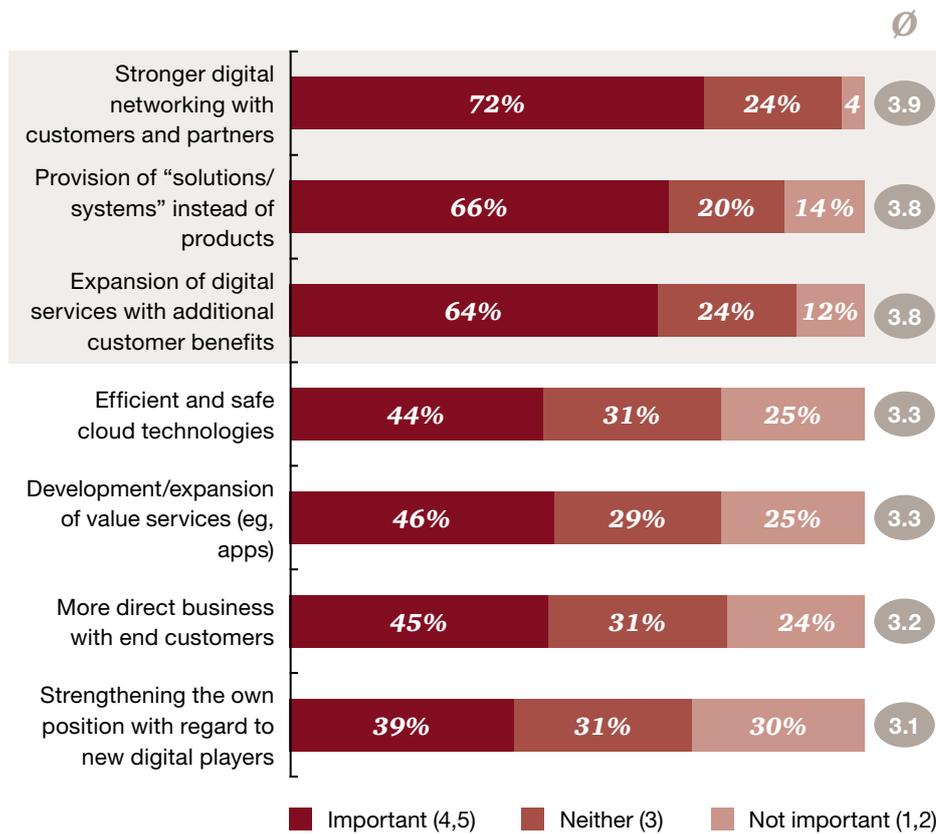
8 The Industrial Internet paves the way for new, often disruptive digital business models.

In the course of the Industrial Internet, existing business models will change permanently and in particular, new, digital business models will be created. The focal point for this development is the increase of customer benefits due to a growing range of value-added solutions (instead of products). It further includes the expansion of digital service elements and the increased

connectivity between products, manufacturing equipment as well as customers and partners. The special quality of digital change therefore lies in the rapid acceleration of change. Disruptive innovations will also cause industry sectors like the information and communications industry to change permanently within a short period of time.

Fig. 18 A sustained successful business model requires a combination of multiple aspects of Industry 4.0

Key aspects of successful business models in the context of Industry 4.0



“New, digital business models will expand the existing product and service portfolio in order to ensure future growth in sales.”
Head of Service, manufacturer of printing machines

Established business models will become more data-based, efficient and customer-focused due to the increased connectivity and use of data/analytical abilities in all processes. Consequently, the companies surveyed have referred to “improved planning and control abilities” and “greater customer satisfaction” as the two most important qualitative benefits of Industry 4.0.

The efficient and integrated use of data and the increasing digitization of products and value chains represent the focus of the new business models. In recent years, companies have even developed business models in which the value add is primarily based on the use of data. As in the case of Google, this data is obtained by providing often free digitized products. However, new business models are mainly about using digitization in order to break up established value chains and thus open new sources of income which could not be opened with the previous business model. As a result, new business models lead to completely new customer benefits.

Of all the industry sectors surveyed, the information and communications industry is the most advanced with regard to the development of such new business models. Cloud-based and as-a-service business models have already established and asserted themselves as a standard with respect to the use of IT infrastructures and IT applications. Similarly, classic manufacturing industries like production and engineering will offer more solution-oriented usage models instead of the pure sale of physical products. Machines and systems will be flexibly billed based on consumption (eg, “printed pages” instead of “printers” or “printing machines”). The data obtained from the operation of the systems will be used, in turn, to create new added value (eg, as a “broker of print orders” with optimised utilisation of capacities over different systems).

Conversely, the opportunity to launch new, digital business models on the market by means of disruptive innovations has already led to material changes for entire industry branches.

In the telecommunications industry, for example, digital providers have initiated significant shifts in the value-added process and redistributions at the expense of the established providers.

Similar changes through disruptive digital business models must also be expected in other sectors like the automotive industry. A concept recently patented by Google foresees offering driverless vehicles in cities. Such vehicles are intended to transport the customer from one location to another without a driver. In this case, Google’s added value is created by giving advertisers the opportunity to bring customers to their own shop free of charge and to solve a classic problem for retail businesses at the same time. Such a new business model would certainly have disruptive effects on the high number of mobility providers.

9 Horizontal co-operation allows for improved satisfaction of customer requirements.

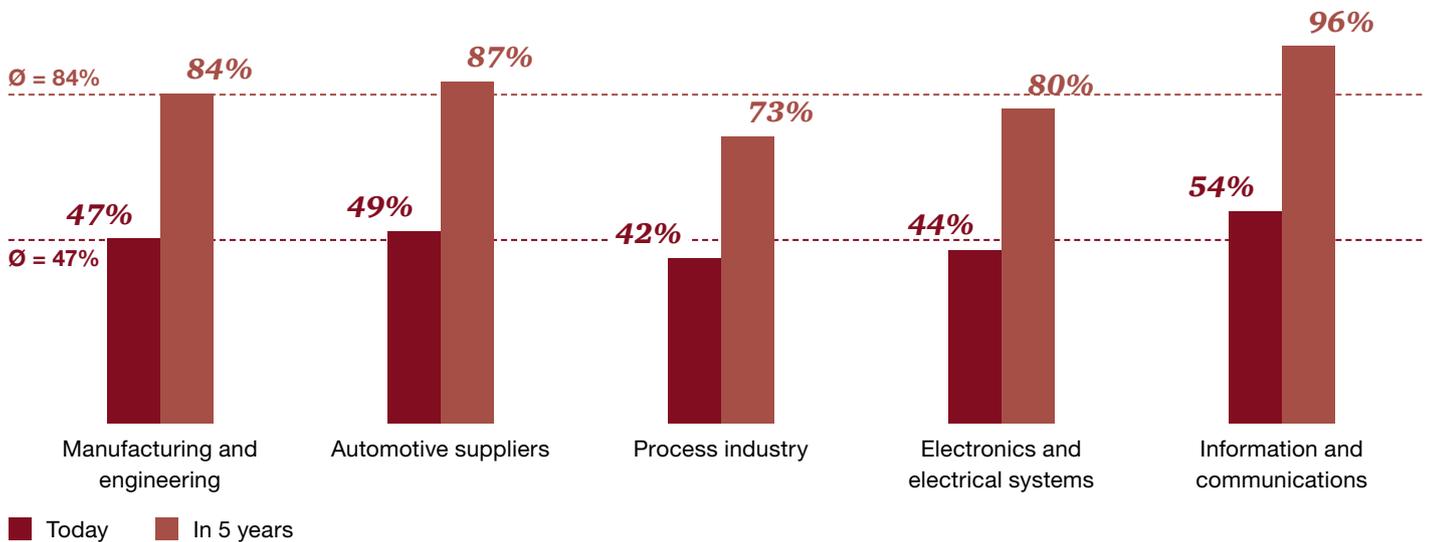
About half of all companies surveyed are convinced that closer co-operation with value chain partners – combined with increased horizontal integration is already of very high importance today. This importance will increase considerably further given the growing level of digitization and connectivity. As far as the next five years are

concerned, more than 80% of the companies surveyed expect that closer co-operation and increased horizontal integration will be of great importance. This likewise applies to all industry branches surveyed and both for users as well as providers of Industrial Internet solutions.

Fig. 19 All industry sectors are focusing on cooperation and horizontal networking to a greater extent

Importance of closer cooperation with value chain partners

Proportion of companies placing high importance on cooperation (4,5)



The main driving force for closer co-operation and increased integration with other companies is the better satisfaction of customer needs in the context of new, digital business models. Shorter time to market and a higher innovation speed as well as an efficient

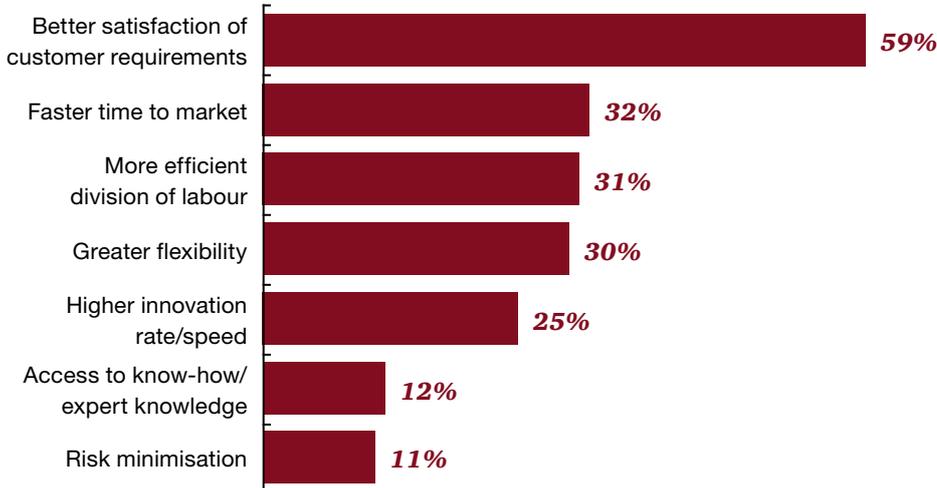
division of labour, combined with more flexibility, are further reasons for the intensification of co-operation. According to the companies surveyed, the access to expert know-how and the minimisation of risks play a less important role.

“The German middle market can only meet increasing customer requirements through far-reaching co-operation.”
 Head of Supply Chain, machine and plant engineer and constructor

Fig. 20 The main driver for closer cooperation is the ability to better satisfy customer requirements

Most important reasons for co-operation in the context of Industry 4.0

Selection of the top 2 reasons (percentage)



In an increasingly complex world, ground-breaking innovations are often only possible by involving a variety of companies. New business models can only be developed when several companies contribute their respective complementary competences. A good example of closer cooperation beyond value chains is the development of electric mobility. Automotive manufacturers have merged in interdisciplinary partnerships with suppliers and different providers from other industry branches (eg, chemical companies and material manufacturers of battery cells, component manufacturers of electronic modules). These partnerships allow them to find new solutions for changed customer needs more quickly and efficiently.

However, closer horizontal partnerships are not restricted to the field of innovation. In fact, their objective is to optimise business processes across value chains – in particular by means of improved analysis and use of data. More than 70% of the companies surveyed believe that the improved exchange of data with cooperation partners in the context of Industry 4.0 will be important in the future.

Finally, the competitive landscape is expected to fundamentally change due to closer horizontal co-operation. Companies that are part of a partner ecosystem are progressively competing together against other companies or other partner ecosystems. In this system, they profit from a more

robust exchange of data and common standards that allow them to stand out on the market and to offer customers higher added value. This is most evident in the information and communications industry. Future horizontal co-operation is considered to be important by more than 96% of the companies in this sector. This trend will very likely extend to the processing industry as well.

10

10 The Industrial Internet holds various challenges – policy-makers and industrial associations can help.

The Industrial Internet is already a key subject for all of the industry sectors we surveyed – and this trend will become increasingly more important in the future. However, companies still have to take on numerous challenges for the successful, timely implementation of digital concepts. In this respect, focus is on the expected high investment levels and the often unclear cost-benefits for new Industry 4.0 applications.

Nearly half of the respondents (46%) stated that the unclear economic benefits and the prohibitively high investments are two of the most important challenges. Many companies have not developed any specific plans for the implementation of Industry 4.0 solutions and have also not made any larger investments. This is because the solutions are new for many companies and require significant changes. The quantification of potentials is also complex and diverse. There is an urgent need for more transparency and an exchange of experience across industry sectors.

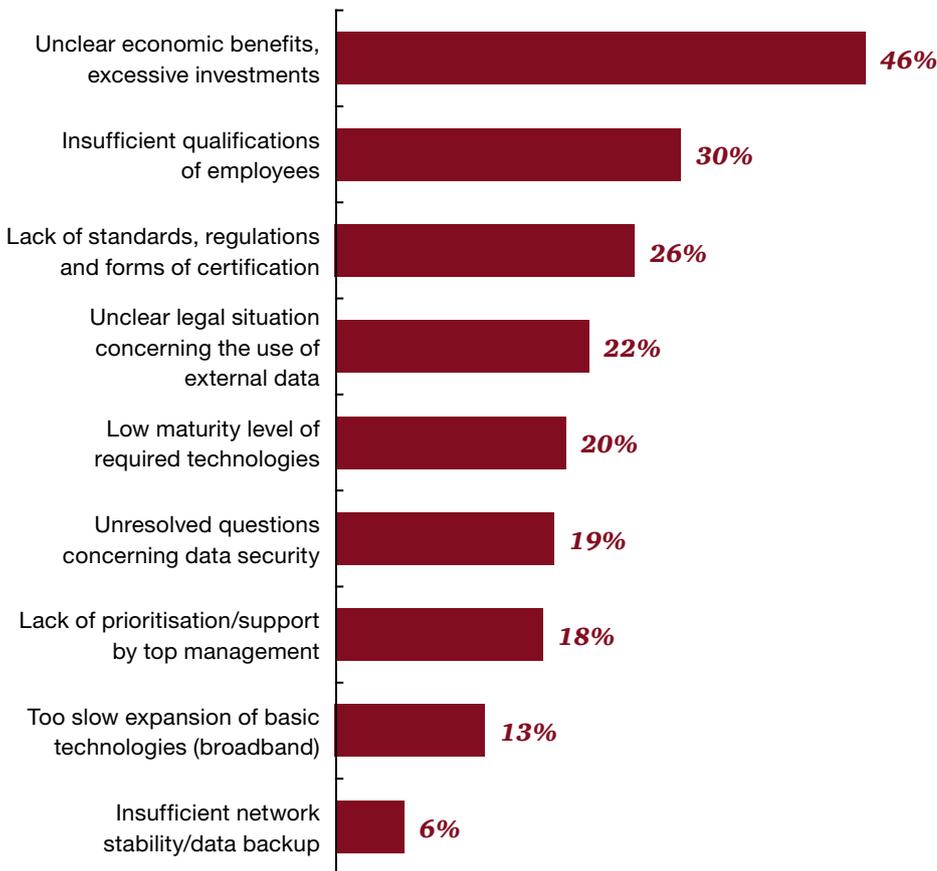
Place two and three on the list are the topics “insufficient qualification of employees” (30%) and “lack of (agreed upon) standards” (26%). Employee qualification is an important topic across all industry sectors. The digital change will alter requirements for employees across all steps of the value chain – from development on through production to sales. Processes and business models will become more agile and data-based, and require completely new employee skills and qualifications. The need for software developers and data analysts in industry also will once again significantly increase in the next five to ten years.



“*If we do not succeed in establishing uniform standards for the exchange of information and data, then Industry 4.0 will fail.*”
Developer, manufacturer of automation solutions

Fig. 21 The lack of clarity about economic benefits is the greatest challenge for Industry 4.0

Challenges for the successful implementation of Industry 4.0
 Selection of the top 2 reasons (percentage)



The broad range of the numerous and complex challenges cannot be overcome by companies alone, but also demand joint efforts by industrial associations, trade unions and employer’s associations. Besides cross-sector cooperation to promote qualifications and to determine and select standards, structuring technological and digital change in Germany needs explicit support by policy-makers.

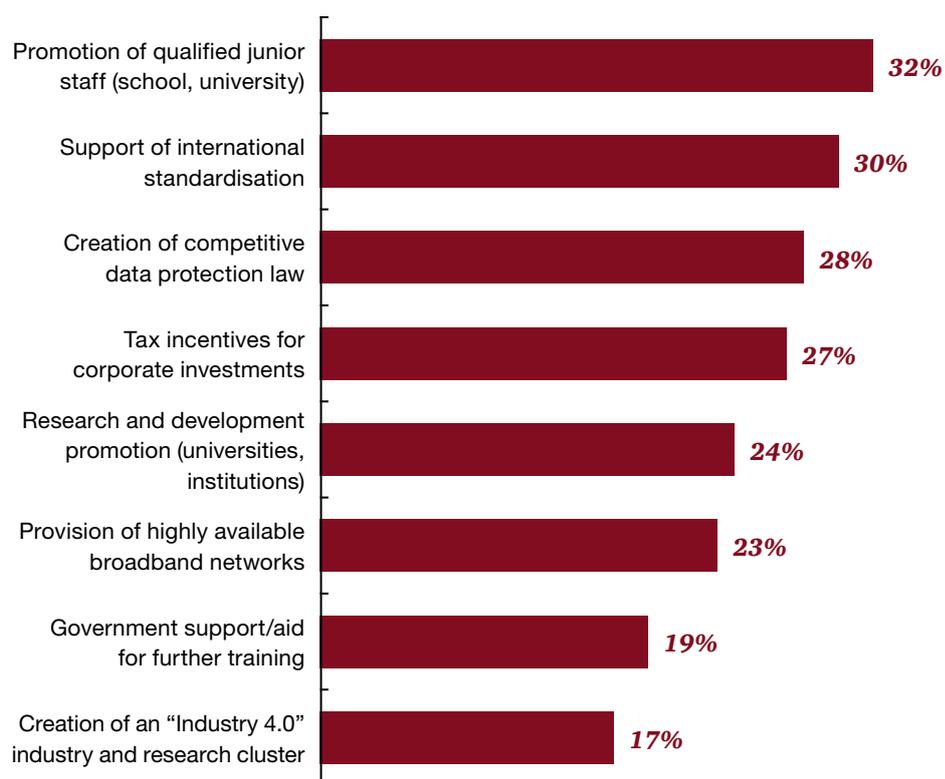
The list of demands that the companies surveyed place on policy-makers is long. The most often mentioned topic for which the companies need help from policy-makers include the promotion of young entrepreneurs, international standardisation and competitive data protection laws. On the other hand, the topic “Expansion of the broadband connection”, much discussed by policy-makers, was relegated to one of the bottom places. Only a few companies thus regard this topic as a big challenge in the context of the implementation of Industry 4.0.

The promotion of young entrepreneurs is more important than ever against the backdrop of demographic change. Policy-makers can help to handle the increasing need for well-trained employees – starting in school. Through the Industrial Internet and growing digitization, the need for employees with a foundation in mathematics, data science and information technology in particular will increase. Policy-makers should create the basis for the education that is required. They need to encourage enthusiasm for technology starting at an early stage. In addition, the contents of vocational trades and study courses must be adapted to the future requirements of the digital world.

Fig. 22 Successful implementation of Industry 4.0 requires the widespread support by policy-makers

Need for support by policy-makers

Selection of the top 2 reasons (percentage)



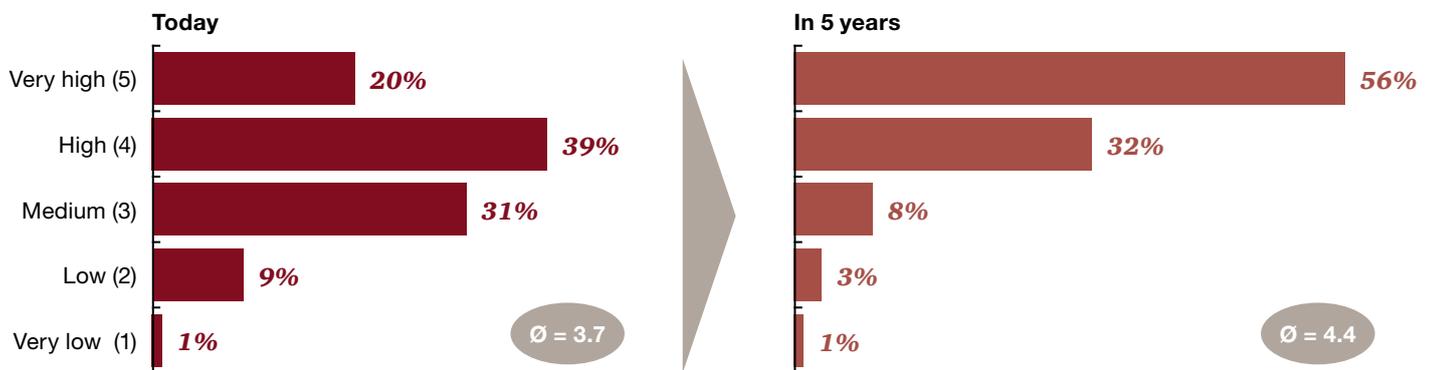
“Industry 4.0 counteracts the relocation of jobs to low-income countries and enables even older employees to work in the manufacturing industry.”
 Developer, manufacturer of automation solutions

Furthermore, policy-makers can provide support by promoting uniform industrial standards at the European or international level. Clearly defined standards and regulations are the basis for the horizontal and vertical connection of value chains. They allow for the seamless exchange of data and information on machines, systems and software. International standardisation is indispensable for Germany, the global export champion, and the majority of industrial companies.

When companies, associations, trade unions and policy-makers cooperate, Industry 4.0 can sustainably strengthen the competitiveness of European businesses and industrial locations in the age of digitization. Nearly 90% of the companies surveyed attach great importance to Industry 4.0 for the German economy in the next five years. More than 50% of the study's participants even deem Industry 4.0 to be fundamentally important for Germany as a business location.

Fig. 23 Industry 4.0 is of great importance for the competitiveness of Germany as a business location

Importance of Industry 4.0 for Germany as a business location



The Industrial Internet – Create change, use potentials!

Digitization will have a permanent effect on our living and working environment. This development offers the full range of opportunities for the industrial sector to expand its leading global position. However, whether Germany, as an industrial nation, can turn Industry 4.0 into a business model does not just depend on the sector's companies. A material framework must be agreed on with policy-makers and society.

Germany's machine construction companies want to make use of Industry 4.0 and take the chance to position themselves as the sector's lead market and lead supplier. Industry 4.0 is about nothing less than the universal language of manufacturing – and this language should come from Germany. Companies are dealing with a fundamental change. Production processes and products are being digitized; manufacturers, suppliers and customers are establishing closer networks and innovation cycles are being further reduced. Production is becoming more individual, resource-efficient, flexible and faster.

This study shows that machine construction companies of all sizes are concentrating on Industry 4.0 and will make considerable investments

in the corresponding technologies in coming years. Thirty percent of machine construction products already consist of software and automation technology – and this proportion will rise significantly.

The study also confirms that there are still substantial questions and uncertainties at many companies. There are no “recipes” or “blueprints” for Industry 4.0 yet. Each company must find its own approach and answer several questions in the process:

- What benefits can my company get from Industry 4.0?
- What adjustments to the business model have to be implemented?
- In which form is Industry 4.0 useful for my company?
- What implementation strategies and investments does my company need?
- Which measures must be applied to train employees?
- How does coordination and integration with existing production technologies, IT systems and datasets take place?
- Of which value-added connections is my company a member?

The German Engineering Association (Verband Deutscher Maschinen- und Anlagenbau e.V., or VDMA) actively supports and shapes this transition of companies towards Industry 4.0. The VDMA combines the interdisciplinary

expert knowledge of the association with that of the companies in a VDMA Forum Industry 4.0. With this forum and the joint platform of VDMA, the Association of Electrical Engineering and Electronics Industry (Zentralverband Elektrotechnik- und Elektronikindustrie e.V., or ZVEI) and the Federal Association for Information Technology, Telecommunications and New Media (Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V., or BITKOM), we are committed to promoting the vision of Industry 4.0 by developing realisable recommendations for action in manufacturing and engineering. In this context, special focus is placed on the user perspective. The objective is to build a long-term and sustainable network to exchange experience among the member companies.



Dietmar Goericke
VDMA Forum Industry 4.0,
Managing Director

translated from German

D Outlook and recommendations



“We already have many digital initiatives in our company – but no shared vision and roadmap in terms of where we want to go with Industry 4.0.”
CEO, machine and plant engineer

The implementation of the Industrial Internet represents a multi-year transformation process for the majority of companies, resulting in significant changes to their value chains. Due to the extent of the expected company-wide changes and the investments required in the next three to five years, it is first necessary for top management to recognise the importance of the topic, place it on the agenda and drive it to a high priority level within companies.

In light of the importance of the Industrial Internet, the statement made by 18% of the companies surveyed about the “lack of prioritisation/support by top management” being one of the most significant challenges, should alarm many management boards and CXOs. At the same time, it is advisable for each company to review the existing competences for Industry 4.0 and define its digitization objectives, particularly with regard to the changes in customer demand.

Our maturity model for the Industrial Internet or Industry 4.0 can help companies to systematically record existing competences and various measures in the field of digitization, and to join them all into ongoing and planned activities in one integrated Industry 4.0 strategy. The areas of processes/value chains, product/service

portfolios and customer/market entry should be fully taken into account as part of this process. The starting point is to have each company assess its own current maturity level and to take stock of its own competences and digital initiatives at the company itself. The Industry 4.0 target maturity is then defined on this basis and possible loopholes can be identified.

The target and the way to achieve it will, however, not be the same for every company. What is more important is to determine the target maturity level suitable for the respective company in relation to the different dimensions. The required competences for the next three to five years, depending on the individual starting position, the customer and competitive situation as well as the willingness to invest must all also be ascertained. Three different strategic approaches can generally be chosen in this context:

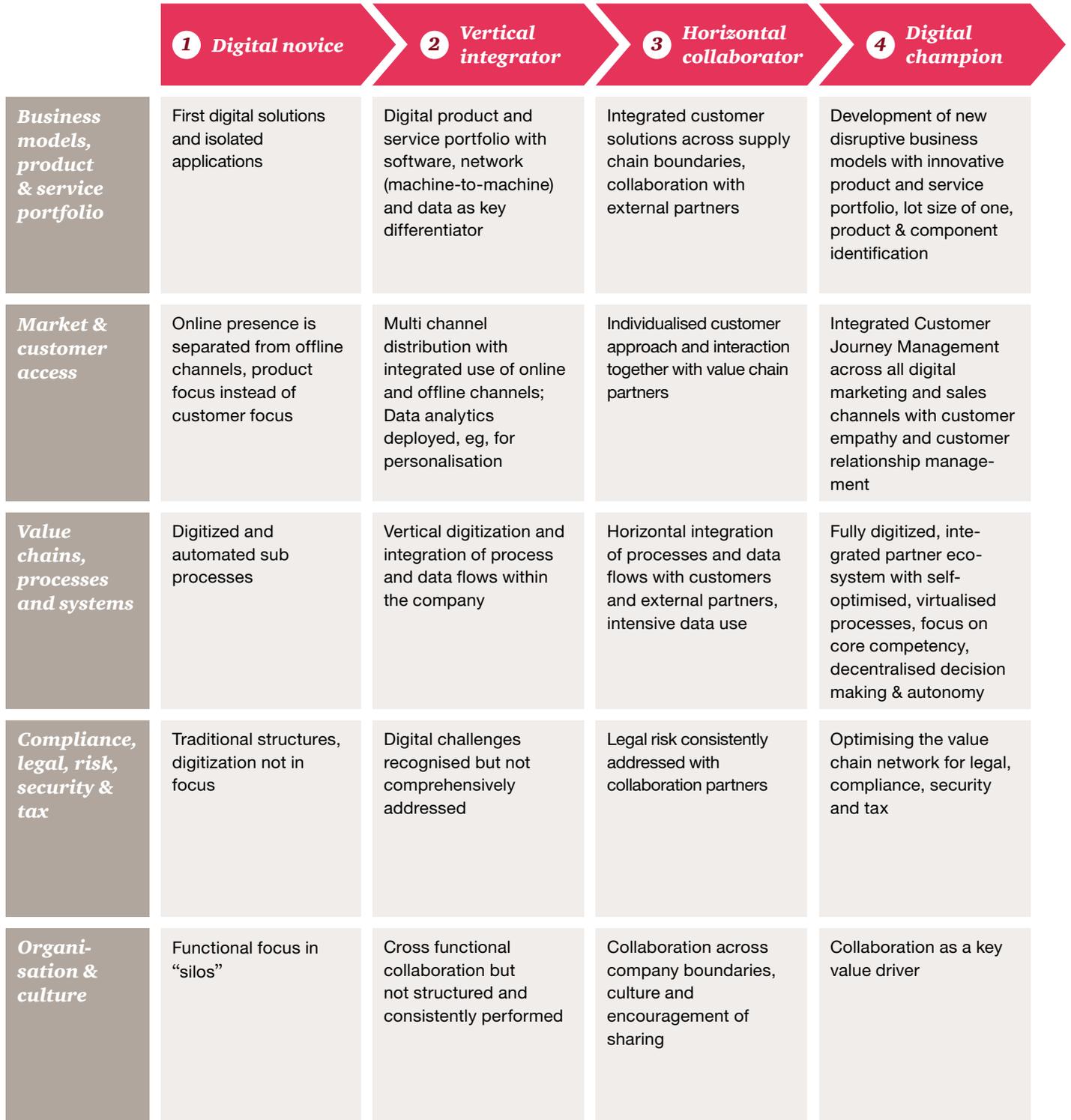
“Leading”: Companies acting quickly while taking risks in order to use the opportunities of digitization early on: co-development of concepts of Industry 4.0 and possibly even creation of actual standards – however, combined with the higher risk of having to first develop and implement new and yet untested solutions.

- **“Adapting quickly”:** Companies learning from the initial experience of the pioneers and quickly adjusting and implementing evidently successful concepts for themselves – however, combined with the risk of not being able to make use of the full potential any more.
- **“Waiting”:** Companies waiting for a broad implementation of Industry 4.0 solutions in order to rely solely on already-tested concepts with defined standards and established profitability analyses – however, combined with the not to be underestimated danger of having fallen behind global competition in a rapidly changing world.

Precise steps for pragmatic implementation, including important milestones as well as the required competences and resources, can be determined in the context of comparing the advantages and disadvantages in light of the defined target. The results

are clearly defined measures backed up with specific profitability analyses and schedules specific to each company. Change management should be set up which helps to secure change in the long-term and to show fast achievements with selected pilot projects.

Fig. 24 Industry 4.0 capabilities develop across five dimensions and four stages



Digital novice

Industrial companies often start off as digital novices on their path to the fourth industrial revolution. At this maturity level, initial positive digitization results have been achieved in all departments as well as in the individual product and service portfolios. However, the activities are neither coordinated nor geared towards a stringent schedule for the future. Digital risks are not recorded systematically and compliance is not guaranteed in all areas.

Vertical integrator

Industrial companies at the second maturity level have already given their product and service portfolio digital functions as vertical integrators. For example, companies may use integrated software (“embedded systems”) and an online connection allowing an internet-based communication of the product with the production materials. The operative processes as well as important administrative processes are digitized. Data from product development, for example, is now available for physical manufacturing environments, logistics and all systems of the company. The functions of an online presence are used for the market entry, for example, by means of detailed websites and online product catalogues.

Horizontal collaborator

Horizontal collaborators on the third maturity level integrate their value chains with customers and partners. The digital integration of customers, suppliers and subcontractors along the production process, as well as better coordination and connections with logistics service providers, can create efficiency and higher quality, improve the processing time or reduce operating costs. The product and service portfolio is connected with external value chain partners to the same extent in order to offer customers end-to-end solutions across several steps of the value chain. Innovative concepts optimise customer communication, and customer information is saved and analysed specifically for an optimal communication. Digital risks are managed with standardised and efficient methods and compliance is maintained for all functions at the company.

Digital champion

The digital champion has connected its operative and administrative processes on a global scale and will also have virtualised these processes in many areas. The company focusses its operational performance on key areas and works with a global network of partners.

The key administrative processes are digitized and globally optimised according to cost and control criteria. Digital champions have often established a “digital headquarters” in which all administrative processes are optimised and frequently automated. Important value chain steps are also efficiently positioned from a financial perspective. The digitized product and service portfolio has been expanded by new, partially disruptive business models. Along with innovative systems and value-added services, these new models incorporate new methods of performance – often with partners – along the value chain. The main focus of necessary competences is on stringent data management as well as efficient analytics and utilisation of (real time) data for optimisation along the value chain.

The development of Industrial Internet solutions requires high investment levels. The economic benefit and possible competitive advantage of these solutions must be critically assessed on a regular basis. There are many ways to become a digital champion, and each company must determine which path is the most promising one for them to follow. This must be based on its abilities and existing configuration of the product and service portfolio as well as on the operative and administrative processes.

“The ‘Industry 4.0 train’ is leaving the station – companies must decide when the best moment for them to hop on is.

Managing Director, industrial association

First steps on the path to digitization

Regardless of which Industrial Internet or Industry 4.0 strategy companies chose, they can set out on their path to digitization and the application of digital concepts with three very pragmatic steps.

1. Give all things a name

Give all products and production materials a clear ID, for example, with a bar code and thus a unique name. Digitizing and connecting products and the value chain can only be made possible on the basis of clear identification. Data can be collected and a complete digital internal description of products and product components may then be introduced. This fosters efficient inventory and supply chain management.

2. Measure, measure, measure

Measure all process and sensor data along the entire value chain in order to track the current state of products and production materials. Install sensors at multiple measuring points along production and on the products if they are not available already in order to get a comprehensive view. The availability of measuring data allows companies to improve processing times, increase the products' quality and decrease process costs.

3. Connect and analyse

Connect the clearly identified products with their digital specification, their production materials as well as their manufacturing process data. In addition, connect the different sources of data. Create the necessary communications and IT infrastructures in order to achieve connectivity and to be able to combine and analyse data – ideally in real time where possible. In doing so, you pave the way for the initial steps towards big data management. This will allow you to define measures to increase efficiency and optimise quality for your own company as well as for your value chain partners.



E Methodical approach



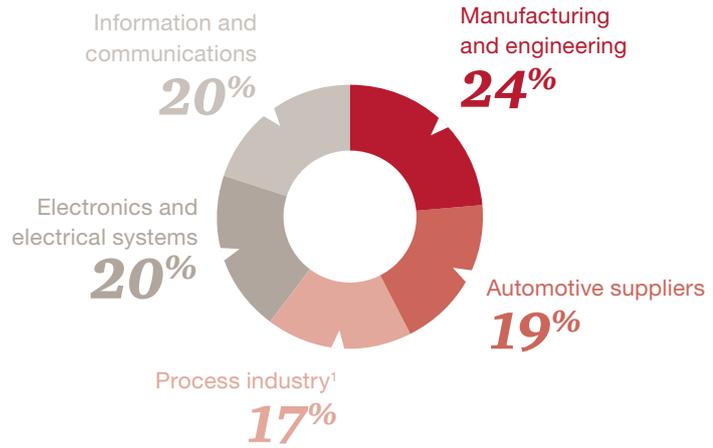
PwC and Strategy& (formerly Booz & Company and Management Engineers) jointly conducted the study *Industry 4.0 – Opportunities and Challenges of the Industrial Internet* in the third quarter of 2014. The analysis was carried out with the kind support of Siemens, the VDMA and the trade journal *Produktion*.

The study surveyed 235 companies from the German processing industry as well as the information and communications industry which were organised into five industry sectors. The survey was carried out in collaboration with the market research institute TNS Emnid by means of telephone interviews and an online questionnaire. Furthermore, employees of PwC and Strategy& conducted personal interviews with select companies.

The participants from different industry sectors represent a balanced mix of both large groups with a sales volume of several billion euros as well as small and medium-sized companies. Fortunately, we managed to attract many companies to the survey that are market leaders in their respective fields at both national and global level.

Fig. 25 Breakdown of the companies surveyed by industry sector

n = 235



¹ Chemicals, petrochemical, pharmaceutical, food, sugar, cellulose, paper, glass, steel, cement.

Fig. 26 Size of the companies surveyed

Annual revenues world-wide
n = 235

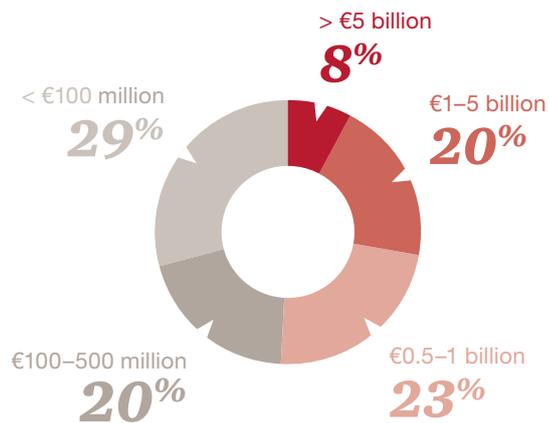
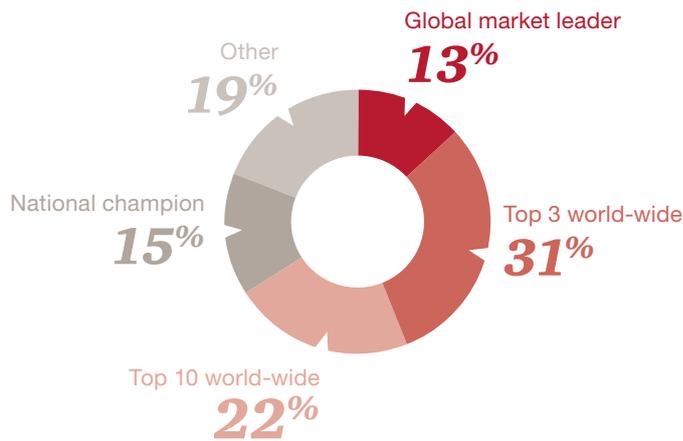
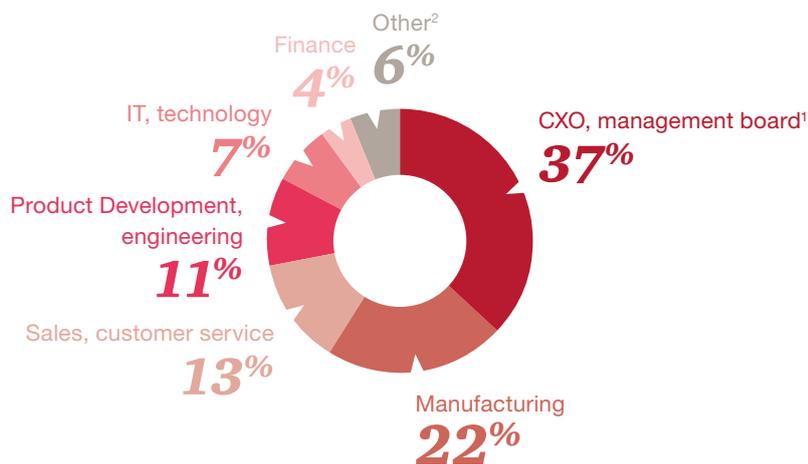


Fig. 27 Market position of the companies surveyed¹

n = 235

¹ Information provided by the companies or survey participants.**Fig. 28 Function of the participants**

n = 235

¹ Including CEO, COO, CIO, CTO, CFO.² Including supply chain/logistics, purchasing.

The seniority of the respondents speaks in favour of the importance of Industry 4.0 for the German economy. Thirty-seven percent of the individuals surveyed are CXOs, executive or managing directors at their companies. Furthermore, attention was paid to a balanced proportion of the functions represented.

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About us

Our clients face diverse challenges, strive to put new ideas into practice and seek expert advice. They turn to us for comprehensive support and practical solutions that deliver maximum value. Whether for a global player, a family business or a public institution, we leverage all of our assets: experience, industry knowledge, high standards of quality, commitment to innovation and the resources of our expert network in 157 countries. Building a trusting and cooperative relationship with our clients is particularly important to us – the better we know and understand our clients' needs, the more effectively we can support them.

PwC. 9,400 dedicated people at 29 locations. €1.55 billion in turnover. The leading auditing and consulting firm in Germany.

According to the ranking at *WirtschaftsWoche*, PwC belongs to Germany's leading consulting companies. In the area of "Business Excellence" – meaning value added for clients – PwC came in at first place. In the opinion of the 1,500 top managers, PwC was the most successful at increasing the operating results in its consulting projects for clients.



About Strategy&

Strategy& is a global team of practice-oriented strategy experts. Our objective is to give our clients that crucial edge at all times. In close cooperation with them, we master their greatest challenges and support them in identifying their opportunities. We have more than 100 years of experience in management consulting and combine it with the unique industrial experience and the resources of PwC. Whether we develop a business strategy, transform a department or build new competences: we create the added value our clients expect from us at all times. We are a member company of the global PwC network.

The name "Strategy&" refers to the companies of the former Booz & Company group and/or to PwC Strategy& (Germany) GmbH (formerly Booz & Company GmbH).

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