

A decorative graphic consisting of a grid of grey dots of varying sizes, with several dots highlighted in red. The dots are arranged in a pattern that roughly outlines the shape of Germany.

Germany's Industry 4.0 strategy

Rhine capitalism in the age of digitalisation

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I. Introduction

»Industry 4.0 is the vital question of Germany's manufacturing industry,« says Joe Kaeser, Chairman of the Board of Directors of Siemens AG. Chancellor Angela Merkel urged the German business elite at the World Economic Forum in Davos in 2015 to act swiftly: »We need to quickly master the amalgamation of the world of the internet with the world of industrial production because the current leaders in the digital area will otherwise take over industrial production.« (Merkel 2015).

The debate about the digitalisation of production has been given fresh stimulus around the world. No other growth discourse has been so strongly pushed by state technology and research policies and at the same time so closely linked to the entrepreneurial and union players in Germany in recent years as the Industry 4.0 discourse. The objective of these activities is to position Germany's manufacturing industry, with political support, as the world's leading user and provider of digitalised production technologies. Contrary to the liberal economies in the Anglo-Saxon context or the authoritarian national economies in the Asian area, this support in Germany does not focus merely on state resources, but also sys-

tematically involves corporate and civil society players. As such, it is indeed appropriate to speak of a revitalisation of cooperative »Rhine« capitalism in the age of digitalisation.

This paper discusses the conditions, potentials, players and prospects associated with the Industry 4.0 strategies. The aim is not merely to generate and use new technical options, but also to examine whether and how the German production model, which, contrary to the disruptive US model for instance, relies on incrementally evolutionary changes, can compete in light of the new challenges. This is associated with the question whether the German players are able to give a structural impetus to the revitalisation of the manufacturing industry, which promises not only technological and commercial progress, but also social; meaning social innovations, such as a better permeability in the work process, new qualifications and further training activities, better options of a positive work-life balance and, ultimately, a reduction in social inequality. Given the relatively early stage of the process and the openness of the developments, there is broad leeway for the players involved to apply their ideas, whether they are companies, associations, parties, unions or the state.

II. Industry 4.0: Not a revolutionary, but an evolutionary enhancement of the production and business model

While digitalisation was long seen as the basis for the service- and science-based society above all, for some time the German debate has focused increasingly on how digitalisation changes the manufacturing industry. The digital interconnection of people, machines and objects changes production processes along the entire industrial value-added process. This offers varied opportunities for increasing the efficiency in production (BCG 2015). The term »Industry 4.0« is an invention of German research politicians, who aimed to circumvent cumbersome headlines such as »Cyber-Physical Systems« (CPS) and explicitly refer to the digital dimension of the future industrial structures.

Industry 4.0 is part of the global mega trends of digitalisation, whose significance is increasing in all areas of life and the economy. The »Internet of Things« and »CPS« are terms that indicate the direction: the idea is a comprehensive interconnection of all elements of the value-added process, starting from the raw materials and pre-products through to customer interconnection and the associated logistics and service processes. By converting analogue data into digital data, the information available in this productivity chain can be used by all players from any location and at any time. On this basis, production and sales processes can be optimized. At the same time, new markets and business areas are created.

The German Industry 4.0 debate with its evolutionary idea of transition and change differs clearly from the dominant debate in the US. The latter emphasises, above all, the disruptive dimension of digitalisation and its potential to crowd out existing production and business models. The German discourse around Industry 4.0, by contrast, identifies further optimisation tools for processes of production and product optimisations that have already been applied in practice for some time. The difference between the US debate as it is being conducted in Silicon Valley, in particular, and the German Industry 4.0 discourse can therefore be best be delimited with the terms of »revolution« and »evolution«.

In order to nevertheless emphasise the break that is associated with Industry 4.0, the process is referred to as the fourth industrial *revolution*, factually however it has more

traits of an *evolution*. After the first industrial revolution symbolised by the steam engine and the mechanisation of industrial processes, followed Ford's production based line of mass production. The third industrial revolution was already characterised by information and communication technology, and resulted in the automation of production methods (Bauernhansl 2014). The smart interconnection of products and processes of industrial production, automation, information and communication technology (ICT) to integrated industrial value-added chains is understood to be the key feature of the fourth industrial revolution (BITKOM/Fraunhofer IAO 2014; Bertschek et al. 2015).

When the report »Deutschlands Zukunft als Produktionsstandort sichern – Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0« [»Securing Germany's future as a production hub – recommended implementations for the future project of Industry 4.0«] was presented in October 2013, it caused a major response in the political system, which occasionally bordered on the euphoric. Industry 4.0 is now considered to be a key target of strategic economic and industrial policy in Germany.

The opportunities of digitalisation for an improved competitiveness of Germany's manufacturing industry can be focused on four dimensions:

1. *Production process*: Digitalisation enables more efficient production processes and therefore cost savings thanks to resource optimization,
2. *Logistics*: Digitalisation enables more efficient flows of goods and information, lower stocks and plant efficiency. It also opens up new business opportunities.
3. *Customer retention*: Digitalisation enables closer customer ties. This results in a more targeted consideration of customer needs.
4. *Hybrid products* and the associated *smart services*: Providing the data on machine monitoring, fault rectification, repair and maintenance via *smart services* justifies higher prices. This, in turn, allows expanding Germany as a high-quality production country in the sense of upscale industrial products.

III. Strengthening the industrial policy paradigm

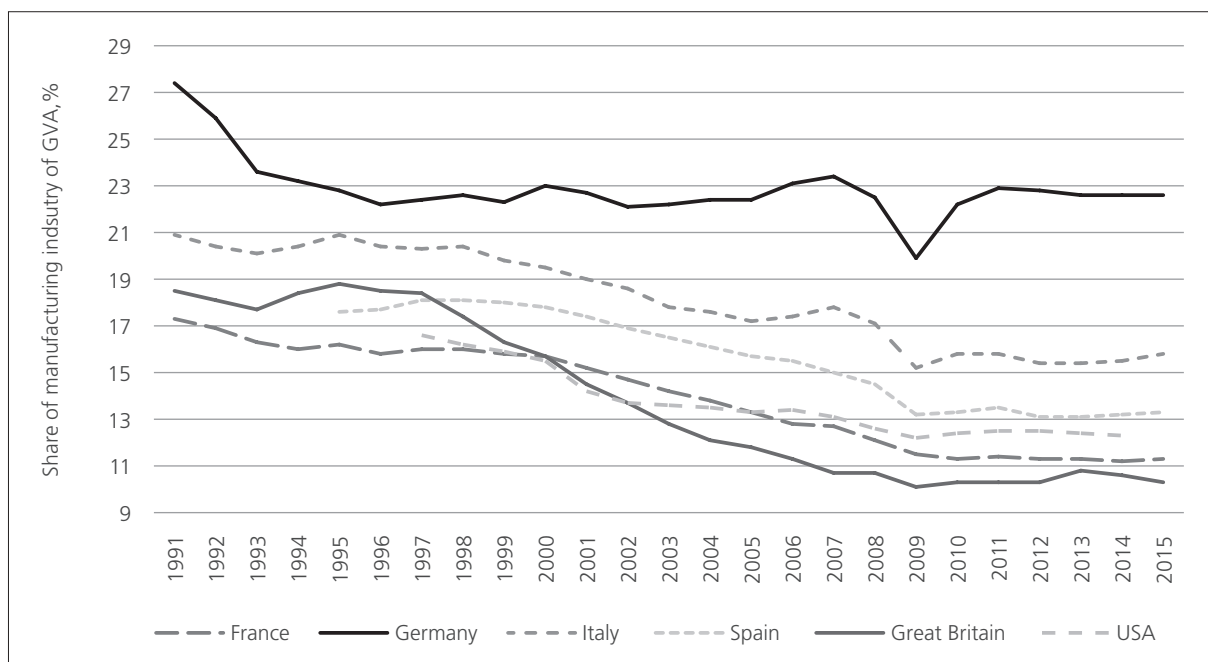
The fact that the term Industry 4.0 is so prevalent in Germany, whereas other terms such as ›digitalisation‹ and ›computerisation‹ and ›second machine age‹ (Brynjolfsson/McAfee 2014) are used abroad, has to do with the role of the manufacturing industry for the German economy. It is considered to be the key to the strategic future debates of the German economy. In other words: It's the manufacturing industry, stupid! For a long time, talk of post-industrial service-based economies (Bell 1973) dominated the debates in OECD countries. This included the Song of Songs of the *new economy*, which was sung until the Big Recession in 2008. In parallel, a dramatic reduction in industrial capacities has taken place in France, the UK and the US over the past 25 years (Fig. 1).

Germany has, by contrast, advanced from the ›sick man of Europe‹ to the currently most stable national economy in Europe by modernising its manufacturing industry. While the industrial share in value added in the UK or France continued to drop, the industrial cores in Germany were not only preserved but also continuously upgraded. In the crisis years of 2008/2009 the manufacturing industry also took a huge hit, but this business

area was nevertheless crucial for the rapid overall economic stabilisation.

The ›farewell to the industrialised nation‹ (Plumpe 2008: 161), pushed by some and feared by others, however, also dominated the German debate for many years. As recently as around 1960 half of the workforce in the Federal Republic of Germany worked in the manufacturing industry; today, this figure stands at only 24 per cent in the narrow context (Federal Statistical Office 2016a). Simple jobs were lost in this process in particular. Nevertheless, Germany is today one of the most industry-dominated countries in the OECD. Processes of ›sectoral specialisation‹ are decisive for the successful adjustment of the manufacturing industry to changed technological, social and competitive environments (Goring/Schierch 2015: 41), which are supported by a strong focus on research-intensive industries. They include primarily electrical engineering, machine engineering, chemicals and vehicle construction (ibid.). Moreover, Germany is not equally dominated by a strong manufacturing industry throughout the country, but has conspicuous regional disparities: the former industrial centres of Germany – the Ruhr area, Saxony, but also the Berlin region – have lost a lot of weight; the industrial hubs today are Baden-Württemberg and Bavaria.

Fig. 1



Tab. 1: Development of the workforce and gross value added (GVA) in the manufacturing industry and in the service sector (in %)

	1970	1980	1990	2000	2010	2015
Workforce: manufacturing industry	35.8	31.2	28.3	19.6	17.4	17.5
Workforce: services sector	45.1	53.8	59.9	69.6	73.9	74.1
GVA: manufacturing industry	36.5	31.0	29.2	23.0	22.2	22.6
GVA: services sector	48.3	56.6	61.0	68.0	69.1	69.0

Source: Federal Statistical Office 2016.

The manufacturing industry contributed 36.7 per cent to gross value added (GVA) in 1970, in 2015 this figure was 22.6 per cent. The service sector generated about 69 per cent of gross value added in 2015. At 48.3 per cent, in 1970 the share was only about half gross value added. The workforce share in the manufacturing industry has shrunk similarly: in 1970 35.8 per cent worked in the manufacturing industry; in 2015 this figure stood at 17.5 per cent. In contrast, about 74.1 per cent of the workforce is employed in the service sector today. However, Germany is still one of the few countries that have managed to retain their manufacturing industry share in GVA over the past 20 years.

These figures overshadow the outstanding significance of the manufacturing industry for the overall economic performance in Germany. They ignore the fact that the growth in services outside the manufacturing industry is merely a result of entrepreneurial outsourcing activities. In other words, the growth outside the manufacturing industry can often not be understood without referring to the industrial capacities. Demand for industrial goods radiates into other sectors and generates orders and jobs there. Business-related services benefit most strongly from this development (Edler/Eickelpasch 2013: 16).

The manufacturing industry in exports plays a particularly important role here. Although the share of services in the overall trade volume has risen tangibly in recent years, trade with goods still dominates. Over the period from 1995 to 2014, the manufacturing industry in

Germany posted a slightly higher growth rate than the overall economy.¹ On average, economic output in the manufacturing industry rose by 1.7% and in the overall economy by 1.4% (Prognos 2016). The growth trajectory in the manufacturing industry is far more volatile. In particular the slump following the recession and the subsequent recovery were above average in the manufacturing industry.

IV. Opportunities and risks of Industry 4.0 in economy and society

The Industry 4.0 debate is currently not just about the question of competitiveness, but also about the question of controlling the consequences of digitalisation for the economy and society. For that reason, the four key economic, social and societal fields are outlined, on which the German digitalisation debate is increasingly focusing: first, the question of productivity development and competitiveness; second; the question of employment; third, the question of qualification and, fourth, the complex of big data and data security.

Productivity and competitiveness

The digital transformation in the manufacturing industry will perhaps only reach its height in a couple of decades. In general, it is assumed that the digitalisation generates sector-specific differences (BITKOM/Fraunhofer IAO 2014). In light of the above potentials within different sectors, most forecasts for Germany expect the key industrial sectors to be able to reach additional value added from the accelerated digitalisation of 1.5 to 2.2 per cent a year until 2025 (BITKOM/Fraunhofer IAO 2014). Tab. 2 shows the different expansion rates of gross value added in real and percentage terms. As an example, the result for machine engineering would be additional value added of EUR 32 billion by 2025.

1. In exports, the share of the manufacturing industry in 2000 stood at 86% and dropped to 79% by 2012. The share of the manufacturing industry in overall imports stood at 76% or 68% in 2000 and 2012 respectively. Even higher is the share of the manufacturing industry in spending on research and development (R&D). If both internal and external R&D expenditure is taken into account, the figure came in at 87% in 2013. The data once again shows the major significance of the research-intensive specialisation of the German industry (Prognos 2016: 18).

Tab. 2: Expected increase in gross value added (GVA) of individual sectors from Industry 4.0

Sector	Increase in gross value added in EUR billion, 2013 to 2025	Annual increase in gross value added in %, 2013 to 2025
Car industry	14.8	1.5
Machine engineering	23.0	2.2
Electrical equipment	12.1	2.2
Chemical industry	12.0	2.2

Source: BITKOM/Fraunhofer IAO 2014.

The majority of the studies, however, expect positive effects that amount to additional value added for the national economy of EUR 20 to 30 billion a year from the greater digitalisation in Germany (BMW 2015a). Reference is made to the fact that digitalisation has already enabled a substantial contribution to increased value added in Germany's manufacturing industry in recent years. For the period from 1998 to 2012, the growth contribution generated by digitalisation amounts to an average of 0.4 per cent a year (Prognos/vbw 2015). This corresponds to one third of the annual increase in gross value added in the manufacturing industry overall.

Employment development

The effects of the considerable rationalisation potentials on the employment development are being discussed in a particularly controversial manner. The focus is not solely on the quantitative dimension, i.e. the question of how many jobs will be newly created or destroyed. It is also being discussed whether there will be a further polarisation of the labour market, how strong the shifts between the businesses and sectors will be and whether this will generate job rotation. With reference to the industrial sector, the question is being discussed whether the fall in industrial employment will continue or whether employment is more likely to stabilise? Previous innovation and rationalisation measures mostly related to employees with low to medium qualifications and replaced their work with machines. It is becoming apparent that the stronger digitalisation will affect virtually all qualification areas. Some observers therefore also expect digitalisation

to have a similar impact on intellectual work as the steam engine and the production line had on physical labour (Ittermann/Niehaus 2015: 40 et seqq.).

The background to the international debate is a frequently quoted study conducted by Frey and Osborne from 2013. The authors assume that some 47 per cent of all employees in the US work in professions in which jobs may be lost from the greater digitalisation in the coming 20 years.² Studies from Germany also come to the conclusion that the major pressure to change and adapt will develop on large parts of the labour market. By applying the approach of Frey and Osborne to Germany, researchers of the Mannheim Centre for European Economic Research (ZEW) (Bonin et al., 2015) came to the conclusion that the likelihood of automation is 42 per cent when directly applying the study to Germany. By shifting the method to the evaluation of activities instead of professions, the result is less alarming: about 12 per cent of jobs in Germany are at risk. As regards the risk structure, there are differences by education and income. Employees with elementary and primary education have an automation risk of 80 per cent in Germany; for those holding doctor's degrees, the figure is only 18 per cent. A similar picture emerges when looking at income levels: with rising incomes, the automation likelihood drops.

With the increasing digitalisation demand for workers rises in the top qualification segment, on the one hand, but falls in the medium qualification segment, on the other. For people without occupational education, in particular, underemployment increases further. The fear that there is hardly any need for industrial unskilled labour in particular, is also shared by other studies and observers: here spectrum of positions ranges from the assumption that in future »there will no longer be any jobs for low-skilled workers in industrial production« (Ittermann/Niehaus 2015: 43) to the possibility of less well-trained people being able to carry out qualified work thanks to technological innovations, such as data glasses and tablets. In the report of the research group, however, this area is viewed rather sceptically: »It is to be assumed that the reduction in simple, manual work will continue. This gives rise to the risk of at least parts of the workforce being excluded (in particular semi-skilled workers). This

2. In this context, it must always be considered that the authors did not aim to determine the quantitative loss of jobs; they do not believe they are in a position to do so considering the unforeseeable wage growth and possible political interventions. They focus on automation likelihood.

would not be acceptable to the employees nor considering the societal aim of social integration – and highly dysfunctional for the successful implementation of Industry 4.0« (Forschungsunion/acatech 2013: 57).

Closely linked to the polarisation assumption is the fear that the devaluation of labour could also reach a fresh quality. This means, in particular, new dimensions of a precarious economy for instance in the form of internet-based crowd-working (Benner 2014). However, diverging prospects are pitted against one another here. By no means all experts come to the conclusion that a reduction in jobs is on the cards. For instance, the Boston Consulting Group speculates that employment can be expected to rise by 6 per cent over the coming 10 years, which will be caused by the rising demand for highly qualified industrial workers in particular (BCG 2015: 8).

Qualification

Industry 4.0 does not mean the end to industrial labour, but a change to it. Technological change and new requirements for work content and processes as well as necessary qualifications and competencies are two sides of the coin. In Germany's Industry 4.0, a comparatively optimistic thinking therefore currently prevails, which emphasises the positive opportunities in the changes. With digitalisation, not only labour and production processes, but also the professional requirement profiles are becoming more demanding, interconnected and more complex. Abstract thinking, information management, process responsibility, documentation and reading skills are becoming more important. Project work, teamwork and shared work processes will also become more important meaning that social competencies will be in greater demand. This will not leave training and study programmes untouched, which will need to be changed against this background (Ittermann/Niehaus 2015: 46 et seqq.).

In line with these changes, further training in Industry 4.0 has a key role. The aim is, on the one hand, to comply with the requirements in the meaning of the Industry 4.0 logic and at the same time to secure and promote the labour market opportunities of the individuals affected. Trade unions, in particular, must act in this regard. The German co-determination right gives them great influence when it comes to training and further education.

Overall, this involves both upgrading training and study courses as well as creating the requirements for successful life-long learning and further training processes for employees. In this sense, the social partner agreement concluded in April 2016 between the employer associations of the metals industry and IG Metall must be referred to as an example. Under this agreement, the training professions being created in this area are to be upgraded jointly (Gesammetall et al. 2016).

Big data – data security

Data security is currently a hot topic in Germany. A lack of data security is not only considered to be an individual risk, but also as a risk for businesses. Espionage from the outside or inside is an omnipresent subject.

In particular the technology-intensive German SMEs are very worried about the risk of their knowledge and information that took so long to develop could be misappropriated in the context of digital-interconnected cooperation structures. Cyberattacks are now also public events, which can damage relationships between sovereign countries. The fears over the integration in digitalised, interconnected, industrial value-added strategies seem to have risen in this context. As such, there are obstacles to the interconnecting of devices and machines as well as integration in external networks. Although these challenges have long been identified, so far no convincing security solutions have been found. In reply to this, two-level interconnection strategies have been established that initially plan for data exchange in a closed network without internet connection (for instance within a factory) and only in a second step the interconnection with external systems.

Companies and authorities can optimise processes with digitalisation and big data, but they can also access and analyse personal data on an unprecedented scale. The ambivalence of big data in the context of Industry 4.0 is also becoming ever clearer: the new, digital-based possibilities of transparency can, on the one hand, result in more egalitarian, more interesting and more demanding work contexts. On the other hand, they enable intensive performance and conduct checks, in the worst case even comprehensive monitoring. In response to this, reforms of the current data protection laws are being called for,

so that the rights of private individuals and the interests of companies and authorities can be better balanced.³

To make digitalisation a success, it is important that the legal, technological and business competencies are better interconnected. As such, the Industry 4.0 strategy raises entirely new liability questions. If, for instance, something goes wrong in production, it may be more difficult in the future to establish who in the chain is responsible. The debate about the data protection law consequences associated with the further digitalisation is only in its infancy.

V. Industry 4.0: Revolutionary idea – evolutionary implementation

The communication strategy for promoting Industry 4.0 has progressed well in Germany to date. By contrast, the real Industry 4.0 practice in the businesses themselves still appears to be underdeveloped. For instance, in 2015 the ›Commission of Experts for Research and Innovation‹ of the German federal government wrote: »The uncertainty over developing industrial standards is leading to hesitation over investments in systems that may be incompatible in the future at medium-sized enterprises in particular (Commission of Experts for Research and Innovation 2015: 31).

Whether and to what degree Industry 4.0 technologies will be rolled out at companies will be guided by the willingness to look into this matter and the possibilities of implementation. A crucial factor for an (early) implementation of new technologies is the size of a company. Major companies produce in large volumes and operate a strategy of permanently optimizing a highly automated production. At SMEs, by contrast, non-automated activities in production are more prevalent. What is more, the products are mostly sold in niche markets and often have a high degree of specialisation (IW Institut der deutschen Wirtschaft Köln Consult 2015; Expert Group 2014; GfK EniGma/DZ Bank 2014; BMWi 2015a).

3. In particular, the revision of the data protection principles, such as the approval, identifiability or purposefulness of data processing, as well as the introduction of new legal concepts, such as the right to be forgotten, product standards or sanction options in the event of data abuse are being discussed. The legal protection of whistle-blowers is also being discussed.

At the same time, there is major discrepancy within the group of SMEs: on the one hand, individual pioneers can be found in the implementation of new technologies. On the other hand, however, there is also global reservation as regards planning and implementation. This reservation is, however, also rooted in the lack of binding standards and norms as well as clear requirements on the part of major companies. Added to this is the uncertainty over a lack of data security and compatibility issues with the automation software. Infrastructure problems, for instance due to a lack of broadband facilities, also contribute to preventing a more active application of Industry 4.0. There is also little risk capital. In particular young companies wanting to stand out with a more disruptive application in the Industry 4.0 segment are having problems with raising capital (Schröder 2016, 11 et seq).

The route to the Industry 4.0 world has without doubt started. However, a rapid, global use of 4.0 technologies cannot be expected. The aim of Germany industrial policy is currently to overcome a lack of acceptance and to establish a global Industry 4.0 landscape. Only then can the desired benefits in the sense of interconnected structures really be achieved. To move towards this objective, reference projects are required. Best practice examples, which show progress in the area of digital interconnection and implementation of new technologies, are being »mapped« by the Ministry of the Economy (<http://www.karten.bmw.de/>). Furthermore, some major companies have their own research factories, such as the TecFabrik of Daimler AG (Daimler 2015), where new logistics and production systems are tested. The transformation process at SMEs is strongly supported by state-promoted research projects. An example here is Wittenstein AG, which is supported with federal funding and is implementing elements of Industry 4.0 in the CyProS research project (BDIa 2015), focusing on digitalisation of supply chain management, on a model basis

VI. Political initiatives and players: steering the Industry 4.0 strategy

There is no political strategic centre in Germany that develops, broadens and steers digitalisation and Industry 4.0. Indeed, there are various initiatives of business, politics, stakeholders and science acting simultaneously. They proceed partly detached from and in competition with one another, but also in a closely interconnected manner

in subareas. Many initiatives are overseen directly by politicians and the state or are initiated or even funded by individual companies with deep resources. Nevertheless, the relationship between state and stakeholders, which was already very durable in the old German corporate industry constellation, also has certain significance in the manufacturing industry. This applies, in particular, for the global coordination of innovations, the setting of standards and the creation of the state infrastructures required for this. This is true especially when it comes to creating the most suitable framework conditions for the infrastructure (e.g. broadband expansion, industrial standards) as well as financial incentives (e.g. taxes, investments) for implementing Industry 4.0.

At the start of the debate around the Industry 4.0 strategy, the initiative was strongly with the individual players from the triangle of politics, companies and science, who cooperated loosely with one another. Over time, at the latest when it came to mobilising more comprehensive resources and the necessary legitimisation, the associations were also included. Not only were the employee associations involved, but also trade unions. The comparatively early inclusion of associations was also due to the experience that in previous major projects that attempted to do without this inclusion, failure soon became apparent, as the resistance was too strong and the legitimisation too weak.

The role of ministries and administration

Ministries are important to bring the various players together, equip initiatives with greater public weight and to support them financially and, not least, to bundle and drive the targets of Industry 4.0 with laws, standards and international arrangements. Several ministries are directly and intensively involved in these processes of Industry 4.0 (see Tab. 4).

Tab. 3: Ministries directly involved in Industry 4.0 policies

Ministry	Areas
Federal Ministry for Economic Affairs and Energy	Industry support, unions and platforms
Federal Ministry of Education and Research	Research support
Federal Ministry of Labour and Social Affairs	Employment, qualification
Federal Ministry of the Interior	Data security
Federal Ministry of Transport and Digital Infrastructure	Infrastructure, broadband wiring
Federal Ministry of Justice and Consumer Protection	Consumer protection, data security

Source: own compilation.

Six federal ministries alone are directly involved in the subject of Industry: the German Federal Ministry for Economic Affairs (BMWi), Labour Ministry (BMAS), Research Ministry (BMBF) and Transport Ministry (BMVI) as well as regarding data security the Ministry of the Interior (BMI) and the Justice Ministry. In 2010 the federal parliament established an inquiry committee Internet and Digital Society, which presented its results in 2013. With the Digital Agenda 2014-2017, the federal government developed a comprehensive work programme, in which the various ministries discuss key points of a comprehensive digitalisation policy in coordination with the parliamentary parties and in inclusion of business, science and civil society. Another key public reference point is the ›National IT Summit‹, a congress that has been organised annually since 2006 by the Federal Ministry for Economic Affairs and is intended to develop and present concepts in order to strengthen Germany as an IT hub (Albrecht 2016: 100 et seq.). The work on the digital agenda is supported by a large number of platforms and unions, e.g. ›Digital Workplace‹.

The Labour Ministry

Considering the consequences of Industry 4.0 for the quantity and quality of employment and qualification, the Labour Ministry has a key and supporting role. To perform this role, the ›Digital Workplace‹ platform was established, which has a tripartisan setup and under-

stands itself to be part of the ›Digital Agenda‹ of the federal government. It is overseen by the Federal Labour Minister and the IG Metall Chairman. This platform deals with flexible work in terms of location and time, employment and further education as well as social protection standards. To enable a stronger involvement of the labour policy players, the ministry has initiated a process that started with a ›Green Book‹ in 2015 and is to end for the time being in 2016 with a ›White Book‹.

The Research Ministry

Key impulses to promoting Industry 4.0 came from the Federal Research Ministry from 2009 and from the Federal Ministry of the Economy from 2014. To have more flexible structures outside the ministries, associations and companies, the Federal Research Ministry established in 2002 the National Academy of Science and Engineering (acatech), where politicians can seek external advice in technical, scientific and technology policy matters. Funding was ensured with institutional support from the federation and the 16 federal states. In addition and closely linked to acatech, the Economy - Science Research Union (Forschungsunion Wirtschaft-Wissenschaft) funded by the federal government and the states, worked between 2006 and 2013 as a further advisory committee of the federal government for its high-tech strategy. This strategy was adopted in 2006 and continued in 2010 as ›High-Tech Strategy 2020‹. The Research Union directed its areas of work to those areas of needs that the federal government stated in the summer of 2010 in its High-Tech Strategy 2020: climate/energy, healthcare/nutrition, mobility, security, communication and social framework conditions.

For the content work on the projects relating to Industry 4.0, various scientific initiatives also play a key role, such as the Munich Group⁴ or renowned, major institutions such as the Fraunhofer Society, which are involved in these processes with their competencies in a varied manner. In this process, the Fraunhofer Institute of Labour Economics and Organisation (IAO) is of particular relevance, as the ›Production Work 4.0 Innovation Network‹ was started from there in 2013, with which industrial companies and research partners jointly work on replies

4. In the Munich Group, 1974 information and communication experts have come together to discuss questions of information and communication technologies (www.muenchner-kreis.de).

and solutions for the future of production work in Germany. The players from the acatech, the Research Union and not least the Fraunhofer Society are the driving forces to give crucial stimuli to the Industry 4.0 campaigns.

The Ministry for Economic Affairs

The start of the industrial policy support for Industry 4.0 was originally announced at the 2013 Hanover fair. In autumn 2015 this initiative was then transferred to a new Industry 4.0 platform, supported jointly by the ministries of the Economy and Research. IG Metall is now also involved in this platform in addition to the business associations under the leadership of the Ministry of the Economy. The key task of the platform is to accelerate the rollout of the Industry 4.0 logic in the Germany economy and to create a suitable framework. The implementation itself should take place outside the platform and follow a competitive logic (BMW 2015b: 11). Five working groups deal with the platform's content focuses:

- Model solutions and standardisation
- Research and innovation
- Security of integrated systems
- Legal framework conditions
- Work, training and further education

Companies and associations of the platform are involved in various initiatives in order to accelerate the standardisation and practice transfer in Industry 4.0. At the same time, a cooperation was established in 2016 with the ›US Industrial Internet Consortium‹ to ensure a future interoperability of the systems and associated standardisation.

The Industry 4.0 platform, which was established in 2015, is already more successful than its predecessor, as it can show key successes in the area of standardisation in particular. The players involved seem to be aware that the main task is to lower entry obstacles for medium-sized and smaller enterprises in order to make it easier for them to enter Industry 4.0, for instance by enabling SMEs to test newer technologies. The RAMI 4.0 (Reference Architecture Model Industry 4.0) reference model was developed from the platform. It combines the key technological elements of Industry 4.0 and offers companies from various industries a standardised orientation. The platform also supports companies with an online map that shows in 250 application examples where Industry

4.0 is already taking place today in Germany. An online library offers a simple and systematic entry to the subject of Industry 4.0 using practical guidelines, publications and studies (BMW i 2016).

The Alliance for the Manufacturing Industry

The platforms, dialogues and initiatives stated above process the Industry 4.0 subject in terms of content. However, until 2015, there was no deep politically mobilising framework aimed at promoting the acceptance of industrial modernisation processes in society. In this sense, on 25.11.2014 IG Metall, the BDI and Federal Minister of Economic Affairs Sigmar Gabriel took the initiative to prepare the establishment of a ›Future of the Manufacturing Industry‹ alliance. On 3.3.2015 such an alliance was established in Berlin that currently consists of a total of 17 partners.⁵ The coordinating body for the alliance is the Ministry of Economics. The alliance aims to improve the conditions that can influence Germany's industrial competitiveness. On 13 October 2015 the following sub targets for the alliance were set out in a declaration »For a contemporary and sustainability manufacturing industry policy in Germany«: increase industry acceptance, secure competitiveness through investment and innovation, free trade and free competition, understand digitalisation as an opportunity, strengthen industrial policy also in the EU, win specialists also through immigration.

The alliance brings together the industrial policy competencies and facilitates the alignment and coordination processes. The tripartisan arrangement of state, employers' associations and trade unions broadens the legitimisation basis. The »Design of the Future« in the context of digitalisation and Industry 4.0 thereby becomes a common project in which trade unions and employers' associations apply their relevant competencies and interests. Here, the principle applies that the alliance part-

5. In addition to the three players stated in the text, the Future of the Manufacturing Industry alliance consists of the following business associations: German Chemical Industry Association (VCI), German Association of the Automotive Industry (VDA), Mechanical Engineering Industry Association (VDMA), Central Association of the Electrical and Electronic Industry (ZVEI), Main Association of the German Construction Industry (HDB), German Employers' Association (BDA), Metalworkers, German Federation of Chemical Employers' Association (BAVC), German Steel Federation (WV Steel), Association of German Chambers of Industry and Commerce (DIHK). The trade unions involved are the Confederation of German Trade Unions (DGB), the Mining, Chemical, Energy Industries Trade Union (IG BCE), the Construction, Agriculture, Environment Trade Union (IG BAU) as well as the Food, Beverages and Catering Union (NGG) (BMW i 2016; network Future of the Manufacturing Industry n.D.).

ners focus on those subjects whose contents match and where there is no mutual excessive demand.

The allocation acts on four levels:

- On the first level, the High Level Group is to be mentioned, which includes in addition to the Minister of Economics the presidents or chairmen of the employers' association and trade unions, which sets the direction for the alliance.
- The second level is a so-called ›Sherpa group‹ that prepares the decisions of the High Level Group.
- At the third level, five working groups are installed that provide the relevant expertise and political input (see also the annex).
- At the fourth level of the alliance is the ›Network Future of the Manufacturing Industry‹, which was established as an independent association. Most members of the alliance are combined in it. With this construction, it is emphasised that this initiative aims to act independently from the political trends of the government's composition and maintains a direct line to the associations and social initiatives. Beyond this independence, the association considers itself to be an original administrator of the ideas of the alliance and its cooperation partner. The chairmanship and management of the network are performed by representatives of trade associations and by trade unions on an equal basis.

Industrial policy positions of the German players

In the context of the Industry 4.0 scenarios, considerable design options arise for the players involved. The Ministry of Economics aims to implement and legitimise the government's economic and technology policy agenda. The employers work towards a flexibility-driven design, employers' associations are interested in acceptance, subsidiaries and an improved infrastructure, trade unions want to promote the security of employers and have a positive influence on working conditions and co-determination. In this process, the trade unions need to avoid being merely instrumentalised as acceptance generators for the interests of business without anchoring own issues. As such, all parties involved must navigate a tightrope that plays out between the struggle of their own interests and a pragmatic acting towards joint targets.

Government

As the 2013 coalition agreement was adopted at a time when the subject of Industry 4.0 was barely located in the public debate, the positions in the coalition agreement are weaker than the later government practice. The coalition agreement has the improvement of the digital infrastructure at its heart and wants to promote broadband expansion to this end (2013). In addition, the open and free internet on the basis of WIFI and net neutrality is considered to be a key foundation for the further digitalisation of the German economy. As regards the effects on the labour market, on the one hand the transition process is taken into account, which coincides with an increasing digitalisation. On the other hand, the competencies located before professional life are considered in a school context. Opportunities are seen in more flexible forms of work organisation (e.g. Teleworking), which make it easier to balance family life and work. In order to address the associated risks of dislimitation, it will be necessary to strengthen the right to non-availability. This requires boosting the media and information competencies that will need to be supplemented with digital qualification and further training tools.

To ensure the ability to innovate, two focuses can be identified. On the one hand, the expansion of research activities in a national and international context is emphasised. On the other hand, knowledge transfer is given great significance, for instance with centres of excellence, model regions, pilot and union projects and top clusters. For the successful implementation of Industry 4.0 technologies, unification in the area of standardisation, interoperability and certification is necessary, which is to be supported with greater consulting work and by cutting red tape. Venture capital, KfW-financing and the expansion of support instruments aim to increase the innovation potential, which exists not only at start-ups.

The interests of German employers' associations

The Federation of German Industries (BDI 2015b) focuses, in particular on the design of the infrastructure and economic policy framework conditions. One focus is on expanding the digital infrastructure (broadband expansion and Digital Dividend II), in order to master the growing data volumes. A second focus is on the supra-national, in particular European, framework conditions.

This involves implementing the EU data protection regulation that came into force in 2016. Cloud services, the protection from cyber attacks and fighting them as well as the ban on economic espionage play a major role. A third focus includes the specific promotion of company establishment activities (e.g. by providing risk capital, financing via crowd function, strengthening the financing in the company establishment and growth phases) as well as a policy of tax reduction to promote research and a functioning competition in the digital markets. An overarching and fourth focus is targeted innovation promotion, which allows German companies to become the technology leaders in this sector.

The German Employers' Association (BDA 2015) aims to use the Industry 4.0 debate for a company-compliant redesign of labour markets. From this perspective, digitalisation needs to be accompanied by deregulation and flexibilisation of established standards, both as regards remuneration and working hours. The aim must be to move away from a daily maximum of working hours to a weekly maximum of working hours. To achieve greater economic momentum, service contracts, temporary employment and fixed-term employment relationships need to be given greater significance. Furthermore, regulations resulting from co-determination have a limiting effect on faster decision-making and implementation processes. The BDA focuses on the area of education and qualification. To secure the necessary expert potential, the strengthening of MINT education and the teaching of digital competencies at school are required. Further training is seen as the silver bullet, which can be promoted with a workplace-related further training or a work organisation that promotes learning.

The interests of the trade unions

The DGB unions (DGB 2015) insist that the involvement and support of the workforce is the foundation for a successful Industry 4.0 strategy. Qualification and further education questions are central: A corresponding work organisation is the basis for a life-long education culture, which is secured by a forward-looking qualification strategy at a company level, the creation of transparent structures or financial support of the workforce as well as further education laws. This is particularly important against the background of declining jobs for unskilled and semi-skilled workers. As new forms of work, such as

crowd-working are emerging, an adjustment to the employee and business concepts as well as an expansion of the right to co-determination must be carried out. What is more, it will be essential to protect new forms of work by expanding social insurance protection to all forms of gainful employment. Aspects of data protection law in the sense of comprehensive employee data protection needs to be established. For the »Good Work« strategy to have a future within Industry 4.0, it will be necessary to increase research funding, among other things for work research programmes, which happened within the framework of the 2013 coalition agreement.

Social Democratic Party (SPD)

In 2015 the SPD highlighted three areas of action, which it considers to be particularly important in the context of the Industry 4.0 debate. These are the consideration of man in an increasingly digital society, the conditions of economic and social innovation capacities and the framework conditions for the success of Industry 4.0.

In the first point, the party aims to design the changed work conditions within the framework of a stronger co-determination of employees. New forms of work (e.g. crowd funding) are making new standards necessary, which range from the working hours to expanding the support offered for children through to adjusting employment protection. The requirements for a successful Industry 4.0 strategy are laid in the education system. The learning content needs to meet the necessary »digital competencies«. The stronger integration of professional and academic training as well as occupational study programmes should mobilise additional education potential. In addition, the securing of young mathematicians and scientists in the future and reducing the drop-out rate are considered sufficiently.

Targeted innovation is based on the promotion of research-intensive SMEs. By expanding innovation clusters, continuing the so-called excellence initiative at German universities as well as centres of excellence and knowledge platforms, the framework conditions for innovations are to be improved. As there is great innovation potential both from existing SMEs and start-ups, their framework conditions (i.e. through networks with established companies, the provision of venture capital, the


expansion of incubators and founder centres) are to be promoted.

For the implementation of new technologies, the third point refers to the design of the framework conditions. This includes the expansion of the digital infrastructure. Besides, it is necessary to secure net neutrality and data security in general. The implementation of new technologies in a company context requires both standards and norms whose implementation is to be secured at a national or international level.

VII. Conclusion

The performance of the German economy is primarily based on the sectoral specialisation of research-intensive industries. This is accompanied by a »corporate« interlocking of business, science and partial state control as well as a flexible and robust labour market organisation, which focuses on qualified specialists. There are currently strong indications that this strong position of the German manufacturing industry cannot simply be continued. Structural investment and innovation problems are evident. New initiatives need to be taken to open up additional growth opportunities. Industry 4.0 is understood as a project in this sense in order to set new standards and achieve market leadership in key elements of digitalised production.

To position Industry 4.0 as a basis for a new growth cycle, various initiatives and strategies have been pursued since the turn of the millennium. A comprehensive interconnection strategy between the traditional industry and digitalised structures is only gradually developing in Germany. In this process, initiatives aiming to achieve rationalisation jumps from a comprehensive integration of individual parts of the value-added chain are nothing new in Germany. Because the economic success did not materialise as quickly as hoped and U.S. as well as Asian IT groups continue to dominate the market, a certain technological dependence of Germany's manufacturing industry from U.S. and Asian technology groups has occurred. With stronger international cooperation, such as with the »Industrial Internet Consortium«, the attempt is being made to improve the country's own competitiveness.




Industry 4.0 is embedded in the structures of cooperation-based control of German capitalism, which runs from the business to the regional and federal level. In this process, the communicative strategy and the integration of associations and science allowed generating considerable attention. By including trade unions it is also possible to break up the widely criticised technological narrowing and to also understand Industry 4.0 as a project of social innovation and social policy. Just how necessary this is becomes not only apparent from the fact that job cuts, dequalification and new qualification needs on a broad scale are about to occur, but also that new forms of service and behaviour control and social polarisation are to be taken seriously as risks. The field of potential developments ranges from the comprehensive automation-driven loss of simple jobs to qualification upgrades through to new forms of digital work on platforms and in clouds. Industry 4.0 is nevertheless an opportunity for the German model despite all the problems. The key to the success of Industry 4.0 will likely be with the major companies setting the standards, by which SMEs are guided. A more intensive interconnection with the international competitors is also necessary not only at a European level.

It must be noted for the international perspective that the German approach is incremental and evolutionary, also for Industry 4.0. By contrast, from a Schumpeter view of the creative destruction of digitalisation – in particular in the U.S. view – the strategy is also seen as »disruptive« changes. For the German evolutionary route to be a success, the prejudice needs to be invalidated that digitalisation changes everything and that it comes with great uncertainty and a lack of plannability. The route taken is in line with the tradition of Germany's corporate policy of state-associations coordination. This time it involves a close interconnection of business, economics, labour market, research, legal and social subjects and policy areas. In light of the social explosive force inherent in the Industry 4.0 logic, this broad approach should avoid a technological and individual economic narrowing of the digitalisation policy. The objective is a technologically and economically successful policy that has both positive and social-integrative consequences for the overall society.



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Annex

In Tab. 4 the central objectives of the individual working groups and their association leadership are presented systematically.

Tab.4: Working groups of the Future of the Industry alliance

Working group	Objectives of the working group	Management of the working group
AG 1: Acceptance – attractive industry	<ul style="list-style-type: none"> ■ General and industry-specific acceptance deficits of the manufacturing industry, technology, ■ innovations and industry-related infrastructure, ■ Communication strategies: Wealth and manufacturing industry, globalisation and free trade, industrial solution competence for global challenges, ■ Strengthening citizen dialogues on industry-related infrastructure and models of balancing interests 	<ul style="list-style-type: none"> ■ German Chemical Industry Association (VCI) ■ Mining, Chemical, Energy Industries Trade Union (IG BCE)
AG 2: Investment-heavy industries	<ul style="list-style-type: none"> ■ Determining factors of investments by business sizes (referring to BMWi expert committee Strengthening investment in Germany), ■ Stocktaking and quantification of private investment needs; obstacles to upgrading the capital stock, economic policy framework conditions for private investments. ■ State investments in infrastructure (improved transport, energy and communication network infrastructure, integration of private capital and education/further training) 	<ul style="list-style-type: none"> ■ Mechanical Engineering Industry Association (VDMA) ■ Construction, Agriculture, Environment Trade Union (IG BAU)
AG 3: Future of work in the manufacturing industry/ industry-related services	<ul style="list-style-type: none"> ■ New qualification requirements for education and further training ■ New forms of work ■ Securing specialists 	<ul style="list-style-type: none"> ■ German Employers' Associations (BDA) ■ German Trade Union Confederation (DGB)
AG 4: Value-added structures of the future	<ul style="list-style-type: none"> ■ Digitalisation and interconnection of industrial structures ■ Industry taking into account the initiatives of IT Summit, Industry Platform, Platform Innovative Digitalisation of the Economy and other initiatives ■ New forms of company organisation in medium-sized and large enterprises, innovation culture, provision of risk and investment capital 	<ul style="list-style-type: none"> ■ German Electrical and Electronic Manufacturers' Association ■ Metal Industry Trade Union (IG Metall)
AG 5: International competitiveness of the German manufacturing industry	<ul style="list-style-type: none"> ■ The German model: open economy and competitive manufacturing industry ■ Determining factors are, among others: research, innovation and quality 	<ul style="list-style-type: none"> ■ The Federation of German Industries (BDI) ■ Metal Industry Trade Union (IG Metall)

Source: Future of the Manufacturing Industry Network (n.d.); own presentation.



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