WISO DISKURS

12/2018

Daniel Buhr and Thomas Stehnken

INDUSTRY 4.0 AND EUROPEAN INNOVATION POLICY

Big plans, small steps

FRIEDRICH EBERT STIFTUNG

The Friedrich-Ebert-Stiftung

The Friedrich-Ebert-Stiftung (FES) is the oldest political foundation in Germany with a rich tradition dating back to its foundation in 1925. Today, it remains loyal to the legacy of its namesake and campaigns for the core ideas and values of social democracy: freedom, justice and solidarity. It has a close connection to social democracy and free trade unions.

FES promotes the advancement of social democracy, in particular by:

- Political educational work to strengthen civil society;
- Think tanks;
- International cooperation with our international network of offices in more than 100 countries;
- Support for talented young people;
- Maintaining the collective memory of social democracy with archives, libraries and more.

The Division of Economic and Social Policy of the Friedrich-Ebert-Stiftung

The Division of Economic and Social Policy, at the intersection of scholarship, politics, practice and the public, combines analysis and discussion to provide answers to current and fundamental questions of economic and social policy. We provide economic and social policy analyses and develop concepts that we impart in dialogues that we organise between academia, politics, practitioners and the public.

WISO Diskurs

WISO Diskurs are detailed analyses examining political issues and questions, containing sound policy recommendations and contributing to policy consultation on a scholarly basis.

About the authors of this report

Prof. Dr. Daniel Buhr is head of the Steinbeis Transfer Center Social and Technological Innovation and adjunct Professor in the Institute for Political Science at the Eberhard Karls University of Tübingen, Germany.
Dr. Thomas Stehnken works on international/EU issues as a scientific officer at acatech – the German National Academy of Science and Engineering. He is also active as a freelance consultant and lecturer.

The authors would like to kindly thank Dr. Philipp Fink, Dr. Andrä Gärber, the "Sustainable Structural Policy" working group at the Friedrich-Ebert-Stiftung as well as the interviewees for their time, intelligent commentary and helpful suggestions. The considerations, interpretations and analyses are their own and therefore do not necessarily reflect the position of their employers.

Responsible for this publication at the FES is

Dr. Philipp Fink, head of the Working Group on Sustainable Structural Policy and responsible for Climate, Environmental, Energy and Structural Policy in the Division of Economic and Social Policy at the Friedrich-Ebert-Stiftung.

12/2018

WISO DISKURS

Daniel Buhr and Thomas Stehnken

INDUSTRY 4.0 AND EUROPEAN INNOVATION POLICY

Big plans, small steps

PREFACE

The term Industry 4.0 has become synonymous for the industrial production of the future. The concept is linked to hopes for more growth through even more efficient production processes, new business models, more customer-specific manufacturing methods and a deepening enmeshment of industry and services. Consequently, several industrialised countries have created funding programmes for various fields of industry. Likewise, the European Commission has taken up the cause of the digital transformation of the European economy. This does not simply consist of linking up multiple innovation policy programmes. Rather, the European Commission wants to interlink the national initiatives of the EU member states.

The present study by Daniel Buhr and Thomas Stehnken examines exactly who is doing what on the European level in order to exploit the potential of Industry 4.0. Furthermore, the authors portray national programmes which support Industry 4.0 through the examples of Germany, Britain, France and Italy. The authors concern themselves with the main components of innovation policy of the EU Commission and individual member states. They provide clarity on the question of how much control can be exerted on the European level and identify points where concrete actions are needed.

The results of their analysis show that, despite considerable efforts, European innovation policy currently lacks strategic orientation. Instead, the programmes of the European Commission and the member states concentrate solely on funding technology, industrial competitiveness and product innovation. Socio-political aspects of digitalisation – such as the effects of digitalisation on the work environment and social cohesion – are virtually ignored. The opportunities of innovation policy remain largely untapped. The economic and social discrepancy between the member states threatens to grow even wider.

Finally, the authors make specific recommendations – under the banners of more (social) innovation, more Europe and more coordination – and oriented around the idea of inclusive economic growth. In the foreground lies the insight that innovation policy linked with digitalisation must be seen as a multidisciplinary challenge, since the processes of digitalisation impact various areas simultaneously. In order to be able to exploit the full potential of the digital transformation, economic policy must aim for inclusive growth. Instead of being focussed solely on technological developments, a sustainable economic policy must support organisational and societal – and therefore social – innovations, to ensure that everyone profits from the digital dividend.

DR. PHILIPP FINK
Department of Economic and Social Policy
Friedrich-Ebert-Stiftung

SUMMARY

Europe is one of the world's centres of innovation. Twenty-eight member states with more than half a billion inhabitants make the European Union the largest single market worldwide. But Europe is more than just an economic area. According to its founding principles, the European Union stands for peace and freedom, participation and democracy – but also for economic, technical and social progress. The economic success of Europe was always embedded in functioning welfare systems, which offered social participation, social security and social advancement through education as well as the basis for creative development and economic freedom. It is especially important to underscore this in these times of growing digitalisation.

For European innovation policy this means three things: more (social) innovation, more Europe and more coordination. Further development begins with a convincing strategy for the future, but should also be reflected in the budget. Investment in innovation should be increased significantly in the European Union as well as in the individual member states. Digitalisation should be employed to modernise the welfare state. Socio-political aspects of digitalisation – such as the effects on the work environment and social cohesion – belong at the top of the political agenda, especially in light of current developments in other regions of the world. Within this context, closer integration of technical and social innovations, but also of innovation, labour, health and social policy is desirable. What, for example, can digitalisation do to achieve growth, good jobs as well as decent healthcare? In order to make progress, the ESF, the Cohesion Fund and the EFSI could be employed more intensively for digitalisation and innovation projects. Innovation policy would strengthen Europe's position as a place for business and research without losing sight of societal and social progress.

Especially when it comes to the digitalisation of industry, Europe can build upon a solid foundation. Policymakers, therefore, should be aware of the potential the continent has to become a leading market for Industry 4.0, and should work together beyond the limited scope of the "Digital Single Market" and take a leading role in terms of technical but also social standards. This also applies to questions of data protection and data security (e.g. "European Cloud Infrastructures", Single Digital Market or European legal frameworks) as well as the strengthening of Europe as a centre for science and research. Knowledge often grows out of "learning by doing" and "learning by using". People carry this knowledge and are the drivers of innovation, meaning that training, further education and the qualification of people should be a top priority. This does not make basic research obsolete. On the contrary: the very states that lead the Innovation Index (Sweden, Denmark, Finland and Germany) distinguish themselves through a very good, broad public science system.

In the spirit of mission-oriented funding we would recommend that the Directorate General for Research and Innovation plans future work programmes with a systematic eye on innovation and on Industry 4.0 in particular. Here, something like "joint research plus" is thinkable. In other words, the continuation of tried and tested principles of international and interdisciplinary funding linked with new cross-sectional approaches. Furthermore, the position of innovation policy in the EU budget should take a significantly higher priority in the Commission (Vice President) – also when it comes to communication, so that new ideas can take hold all across Europe and arrive where they belong: amongst the people.

1

INTRODUCTION

Industry 4.0, Smart Industry, Industrial Internet, Advanced Manufacturing, Fabbrica Intelligente or L'Industrie du Futur are all terms that stand for a vision of the growing digitalisation, networking and automation of industrial production. Things, data and services, people and machines – in Industry 4.0 everything could be connected to everything else. Existing production, logistical and working processes could change dramatically, resulting in great leaps of productivity. Many studies predict high investment in digitalisation because, thanks to the developments sketched above, an individual item customised according to the wishes of the customer could be produced at the cost of a mass-produced product – in a very short time and through minimal use of resources (Gausemeier/Klocke 2016). Aspects of this vision are already being realised, even though we see divergent developments across Europe depending upon region, industry and size of company.

This transformation is being triggered by a number of technical advancements (e.g. the Internet of Things, Big Data, Artificial Intelligence, 3D printing), which could even accelerate in the coming years, but in which there is still plenty of scope to shape developments. Today, most of the scenarios described above remain a distant dream and belong to the realm of the visionary. In these scenarios – by all means already very successful as isolated solutions in testing – objects communicate directly and independently with one another. They inform one another about what should happen to them, meaning objects become machine-readable. Objects which were previously not fitted with electronic components could get their own IP addresses. Sensors and actuators could ensure that their data could be transferred and processed via scanners and computers. As a result, an internet of things and services arises in which the physical world and the virtual world melt together into so-called cyber-physical systems (Plattform Industrie 4.0 2014). In this system, an "intelligent" workpiece could select and find its way to the next machine or the appropriate factory.

Already today, billions of these "smart" objects – from individual workpieces to production robots to means of transport – are connected to and integrated into worldwide value creation networks. The advantages of these developments are clear: production processes become faster, cheaper, more resource-conserving, more efficient. Moreover, digitalisation and networking make possible direct integration of diverse users with all their wishes and ideas, making possible the affordable individualisation of products and services. The potential of digitalisation seems enormous and affects a large number of industries, from agriculture and energy, logistics, IT and communications, to mechanical engineering and vehicle manufacturing. Therefore, the positive tone of relevant studies by various consulting firms (cf. PwC 2015; BCG 2015; PwC 2014; Bitkom/Fraunhofer IAO 2014; BMWi 2015) comes as no surprise. They predict a productivity boost that could mean an increase in revenue to the tune of €110 billion for European industry over the next five years (European Commission 2015).

Against this backdrop, the European Commission presented in April 2016 the strategy paper "Digitising European Industry" (European Commission 2016). The report proposed the linking of national and regional initiatives and the supporting of investments through strategic partnerships and networks. However, this approach to innovation policy also focused primarily on the "Digital Single Market" and the advancement of technology. The impact of these developments on the workplace and societal co-existence received inadequate consideration – with respect to both the opportunities and potential risks.

The present study hopes to draw attention to this absence by examining innovation policy measures enacted on the European level in order to promote Industry 4.0, and tries to find out where there is room for improvement. In doing so, the paper orients itself around four main questions:

- Who does what on the European level with regards to Industry 4.0?
- What are the main areas of European innovation policy regarding Industry 4.0?
- How much capacity for control does the European level have?
- Where is action required?

2

INNOVATION IN THE ERA OF DIGITALISATION

Often innovation is equated with technical advancement, which is considered to contribute substantially to economic growth thanks to visionary entrepreneurs and promising, groundbreaking, revolutionary technologies and products. Innovation is, however, more than just the technologies that enable new products to be sold on newly created markets – markets that only come into being due to technological advancements. Innovations in telecommunications (telegraph, telephone, radio, television, internet), transport (trains, cars, aeroplanes) as well as health and hygiene (penicillin, x-rays) not only created new markets for products, they also helped solve societal problems. At the same time innovations are always a double-edged sword. Due to their revolutionary nature they can have a negative impact – beginning with natural and environmental disasters, to the loss of the private sphere and freedoms, to unemployment or phenomena such as cyberterrorism, drone or robot wars. These effects must be considered whenever we look at digitalisation and all of the enormous possibilities it brings with it. A large segment of the population harbours fears about such developments. For example, structural transformation caused by increased productivity can have a negative effect on employment and labour relations and, in some cases, even the social fabric. Presumably, it is no coincidence that a single machine (the steam engine) became the symbol of the entire industrial revolution and the emergence of a new system of social relations (Alaja et al. 2016).

In line with Schumpeter's image of "creative destruction", innovations often result in technical, economic and social progress. In other words, they can also be used to tackle societal challenges. If this is the case, technical innovations become "social innovations". Social innovations are advancements which, on the one hand, contribute to the dissemination and diffusion of technical developments on the societal level and, on the other hand, represent practices that are developed and used by affected individuals, groups and organisations and serve to overcome societal challenges (Buhr 2015). According to the Vienna Declaration (2011), social innovations are urgently needed alternatives to technologically oriented innovations, which (by themselves) will not be able to solve the big societal challenges of our time.

However, the impact of technical innovations on society depends how we deal with them. And inevitably that depends upon the political measures taken that are intended to steer the direction of technological innovation. Therefore, in the future, innovation will be faced with a significant creative challenge (Alaja et al. 2016).

2.1 INNOVATION POLICY FOR INDUSTRY 4.0

In an increasingly digitalised, globalised world, innovations seldom occur in isolation. Rather, they occur within systems – in interplay with many different actors, also beyond the boundaries of companies, industries, markets and countries. This is generally true for modern technologies, but in the case of "Industry 4.0" it is true in a unique way because these developments affect many issues at the same time: data protection and data security (safety & security), legal, social and technical standards, business models, the organisation of work. Therefore, digitalisation in general and the area of Industry 4.0 in particular easily found their way onto the political agenda of the European Union, which – like many states around the world – is trying to re-industrialise the continent as a reaction to the economic and financial crisis.

Industry 4.0 falls under the area of responsibility of innovation policy, a political field which in terms of content intersects with many other areas of politics, whose competencies are in turn spread across a number of levels – from the regional and national level to the European level. Accordingly, a multitude of actors is involved in this interplay, referred to today as Multi-Level Governance (Stehnken 2010), and which makes the control and coordination of the political field vastly more complex. Furthermore, in many European states innovation policy has successively expanded and changed, which naturally also influences developments in and around the field of Industry 4.0 accordingly.

2.2 CLASSIFICATION AND TRANSFORMATION OF INNOVATION POLICY

We can identify four ideal types of innovation policy (Buhr 2014) which differ from one another depending on whether they are based on a narrow or broader understanding of innovation and on which objectives they pursue: Do they pursue purely economic interests (logic of competition) or do they strive for societal and social improvements? As shown in Figure 1, a narrow concept of innovation focuses solely on technical advancements and limits itself to individual actors or industries. By opposition, a broader understanding of innovation includes organisational and societal – and therefore social – innovations, and serves the achievement of greater societal objectives – in this case inclusive growth.

Figure 1
Four types of innovation policy

	Modern objectives	**Postmodern objectives**
Narrow innovation concept	Improved competitiveness through strengthening the supply side	Ecological industrial policy
Broader innovation concept	Improved competitiveness through strengthening supply and demand sides	Inclusive growth

Source: Own presentation.

A social innovation is an objective-driven reconfiguration of social practices, with the intention of providing solutions to problems and satisfying needs more effectively than is possible through established practices (Howaldt et al. 2008: 65). A social innovation often serves as societal compensation for scientific-technical progress (Braun-Thürmann 2005), but can actually itself induce a technical innovation. It can therefore have a decisive influence over whether a technical invention becomes a widespread innovation (here we see the contrast to Schumpeter), over which paths and channels it diffuses and which effects it triggers on the way (Franz 2010: 336).

We can observe that increasing digitalisation is causing a closer enmeshment of these types of innovation through processes such as "open innovation". Especially in countries like Sweden, Finland and Denmark, the leading nations in the pertinent rankings (e. g. EU Innovation Union Scoreboard, iit Innovation Capability Indicator), we can observe the ongoing development of innovation policy – away from a limited focus on technical modernisation towards a systemic innovation policy. But this goes much further than purely economic concerns (Alaja et al. 2016). A broader sense of innovation includes participation, all aspects of social justice, contribution and participation and therefore issues of societal cohesion are considered and attempts are made to actively promote social innovations (e. g. through political initiatives such as "Good work", "Two More Healthy Years", "Qualitative Growth", and "Inclusive Growth").

In this context, innovation policy becomes a cross-sectional task whose responsibilities are both vertically and horizontally dispersed across a multi-level system such as the European Union. This makes coordination difficult, especially considering that sometimes very different conceptions exist regarding objectives and the right choice of instruments. While some actors favour the kind of instruments which pursue purely economic objectives (growth, employment, competitiveness), others stress the growing importance of ecological or social aims. Normally, innovation is not an end unto itself, rather it is the vehicle by which certain objectives for society as a whole can be better attained. In the normative sense, innovation policy should look beyond the demands of business and the economy, because not everything that is a success for business is wanted by the population. Thus, micro- and macroeconomic as well as short and long-term objectives are not always necessarily in harmony with one another. Here, too, a (political) correction is required. The abstract objectives outlined above must, therefore, first be translated into concrete innovation policy challenges and problems, which can then, in the next step, be solved by implementing suitable policies (Borras/Edquist 2013). Here, innovation policy can make use of a comprehensive portfolio of steering mechanisms on various political levels – from communities and regions as well as on the level of states, the national level or the European Union (Buhr 2016).

3

THE EUROPEAN LEVEL

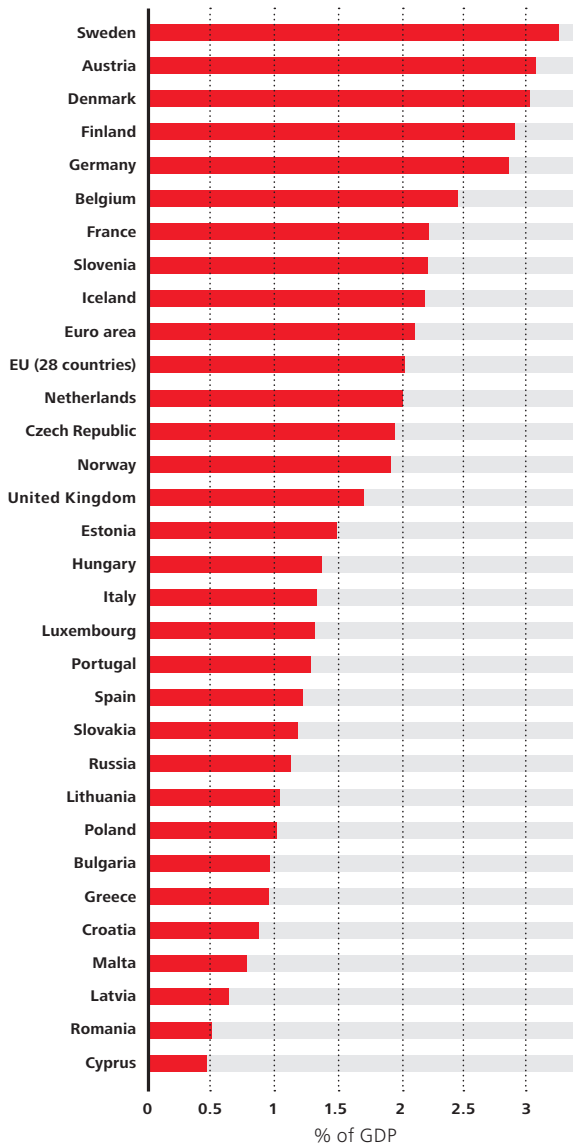
When the Lisbon Strategy was devised in 2000, innovation policy moved to the forefront of European policy. With the Europe 2020 strategy and a budget totalling nearly €80 billion, innovation policy has, at first glance, lost none of its importance – although in times of financial crisis, Brexit and migration it no longer enjoys the significance it once had. While the so-called Juncker Plan places great hope in investment and innovations, this is hard to recognise at the level of concrete programmes (policies) and the corresponding (symbolic) prioritisation of the topic, for example through a dedicated Vice President in the Commission. This weighs especially heavily with a topic such as Industry 4.0 because beyond the Directorate General for Research and Innovation, competences are distributed across various other Directorate Generals (and commissioners) and are therefore increasingly fragmented (e.g. energy, digital, environment, industry etc.).

What still remains of the ambitious goals of the European Commission is the aim that EU countries invest three percent of their GDP on research and development (R&D) by 2020 (one percent public funds, two percent investment by the private sector). Although this goal was set already in 2000, European Union member states are (very) far away from it, not least because of the strict austerity policies of recent years. In the years before the crisis one could observe a gradual convergence of R&D spending – in line with cohesion policy. Likewise, the Smart Specialization Concept of the European Commission (RIS3) aims to use the €454 billion ESIF (European Structural and Investment Funds) to promote innovation even more effectively in the future (European Commission 2014).

All of these efforts are intended to create 3.7 million jobs and increase the annual GDP of the EU by nearly €800 billion. Measures at the European level aim to complement policies on the national and subnational levels, but also pursue their own aims, namely as regional and cohesion policies as well as single market and competition policies.

Here, the European Union possesses the required competences (e.g. competition law or the European Research Area), while in an area such as research policy it has only a divided competence or – as in the field of classic industrial or educational policy – a limited one. Therefore, within large areas of innovation policy, the EU operates with the "soft" steering mechanisms

Figure 2
Total expenditure on research and development
(in % of GDP; 2015)



Source: Eurostat.

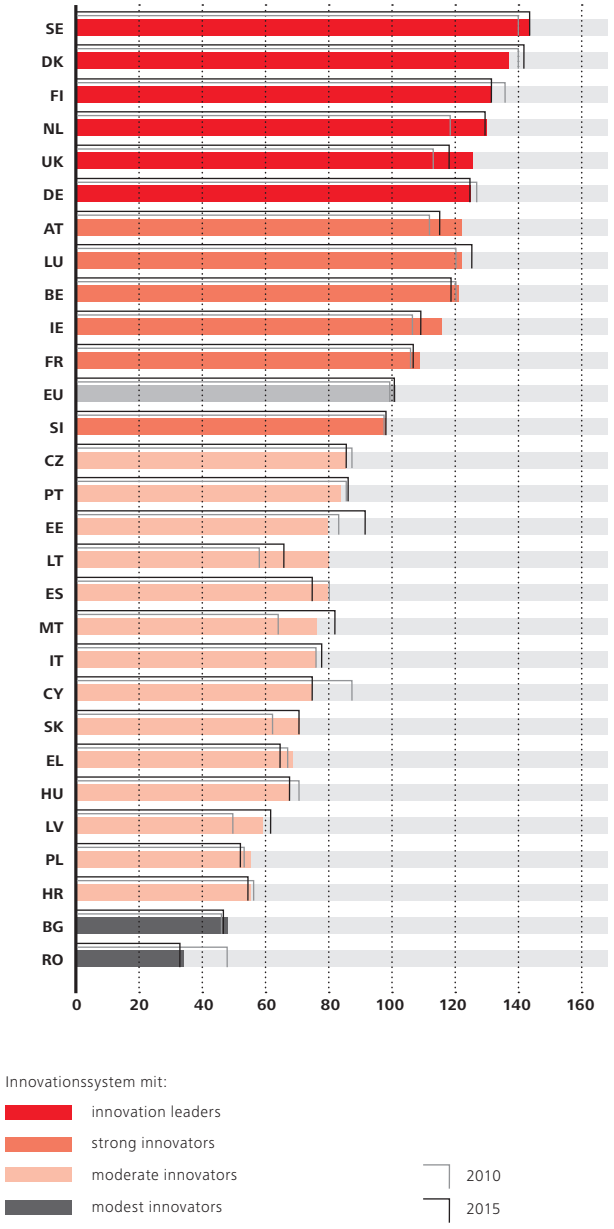
of the Open Method of Coordination (OMC), by which it publishes monitoring reports, makes available benchmarks and databases (e. g. Innovation Union Scoreboard, Digital Scoreboard or the Digital Economy and Society Index) and supports the member states and regions in the development and implementation of their innovation policies (Reillon 2016). Even if the EU does not hold all competences that it requires for a systematic innovation policy, one can, despite everything, recognise a stronger orientation towards innovation since the establishment of Horizon 2020 (cf. European Commission 2014). The so-called "Proof of Concept Programme" in the prestigious ERC (European Research Council), the "Fast Track to Innovation" programme for small and medium-sized enterprises (SMEs) or the expansion of financing possibilities provide good examples of this.

Figure 3
Central framework programmes for European innovation policy

Europe 2020 (European Council, European Commission)	Duration 2010–2020; Key strategy for funding intelligent, sustainable and inclusive growth; 7 flagship initiatives, including "Innovation Union", "Digital Agenda for Europe", "Industrial Policy in the Era of Globalisation" and "Agenda for New Skills and Employment Opportunities"
Horizon 2020	Duration 2014–2020; EU funding programme for research and innovation; budget: ca. €77 billion
"Juncker Plan" (ten-point programme)	Since 2014; agenda of the new Commission; 10 core objectives
European Fund for Strategic Investments (EFSI)	Joint initiative by the European Investment Bank (EIB), the European Investment Fund and the European Commission; objective: overcoming weak investment in Europe through the deployment of resources for economically viable (but also high-risk) enterprises; funding of renewable energies and resource efficiency, but also small and medium-sized enterprises (SMEs)

Source: Own presentation.

Figure 4
European Innovation Scoreboard
(European Commission 2017)



Source: European Innovation Scoreboard (European Commission 2017).[1]

1 The European Innovation Scoreboard compares the performance of national innovation systems and is based upon 27 indicators. In the figure the coloured bars represent the performance of the member states in the year 2016 compared to the EU in 2010. The horizontal bars mark the performance of the member states in 2015 compared to the EU in 2010. The gray bars show the performance of the member states in 2010 compared to the EU in 2010. The same method of measurement was applied to each year. The dotted lines show the threshold values between the performance groups (innovation leaders, strong innovators, moderate innovators, and modest innovatiors) in 2016, whereby the performance of the member states in 2016 was compared to that of the EU in 2016.

3.1 EUROPEAN INNOVATION POLICY WITH A VIEW TO INDUSTRY 4.0

Over the past few years the European Union has addressed the topic of Industry 4.0 with the slogan "Advanced Manufacturing". A taskforce established in 2013 presented a working document (European Commission 2014) which was primarily concerned with the challenge of the shrinking portion of manufacturing in the GDP of the European Union. In this publication on industrial policy titled "For a Renaissance of European Industry" the Commission stressed that digital technologies such as cloud computing, big data, the new industrial internet, applications, smart factories, robotics and 3-D printing were necessary conditions when it came to increasing the productivity of European industry. In the course of other activities on the part of DG GROW (Directorate General for Internal Market, Industry, Entrepreneurship and SMEs) the strategic objective was set to increase industry's share of GDP from ca. 15 to 20 percent (European Commission 2014). The Commission defined three objectives:

- faster commercialisation of advanced manufacturing technologies;
- reduction of demand shortfalls for advanced manufacturing technologies;
- promotion of skills for advanced manufacturing.

3.2 RE-INDUSTRIALISATION OF EUROPE

Likewise, in 2014 the new EU research programme Horizon 2020 was launched – by 2020 the Commission wants to earmark €77 billion of funding, including €24.4 billion for "research excellence" and €17 billion of funding for industrial innovations and so-called key technologies. Here, one can also see the use of innovation policy measures to foster the re-industrialisation of the continent. For example, the Europe 2020 strategy includes seven "Flagship Initiatives", one of which is dedicated to "Integrated Industrial Policy for the Globalisation Era". The European Commission, the European Council and the European Parliament supported this course in recent years. The objective is to significantly increase industry's share of total value creation from 15.1 percent (2013) to 20 percent of GDP by 2020. What stands out here is the fact that this ratio varies enormously between the EU member states – from 24.8 percent (Romania) and 5.3 percent (Luxembourg). With around 22.4 percent in 2012, Germany belonged to the countries with the highest proportion of industry.

3.3 DIGITAL-SINGLE-MARKET

This background is also relevant to the efforts being made to support European industry in the process of digitalisation. The essential content of the funding and regulatory policies of the European Commission were stated in the communication titled "Digitalisation of European Industry" which was presented in April 2016 under the aegis of the Directorate General for Communications Networks, Content and Technology (DG CONNECT). The communication acknowledges the digital transformation and the resulting processes of change (displacement of global value-added chains, new industrial models etc.) and recommends a series of measures to counter these processes. According to the paper, the central precondition for the creation of digital innovation for industry is the strategy of the Single Digital Market (European Commission 2015). Furthermore, national and regional initiatives are to be connected and investments are to be supported through strategic partnerships and networks, which the European Commission hopes will alone generate around €50 billion in public and private investment in the digitalisation of industry:

- €37 billion investment in digital innovations;
- €500 million of European funds plus €5 billion of national and regional funding for so-called "Digital Innovation Hubs" (DIH);
- €6.3 billion for the first production lines of "Next-Generation Electronic Components";
- .€6.7 billion for the European Cloud Initiative.

3.4 GOALS OF EUROPEAN INNOVATION POLICY

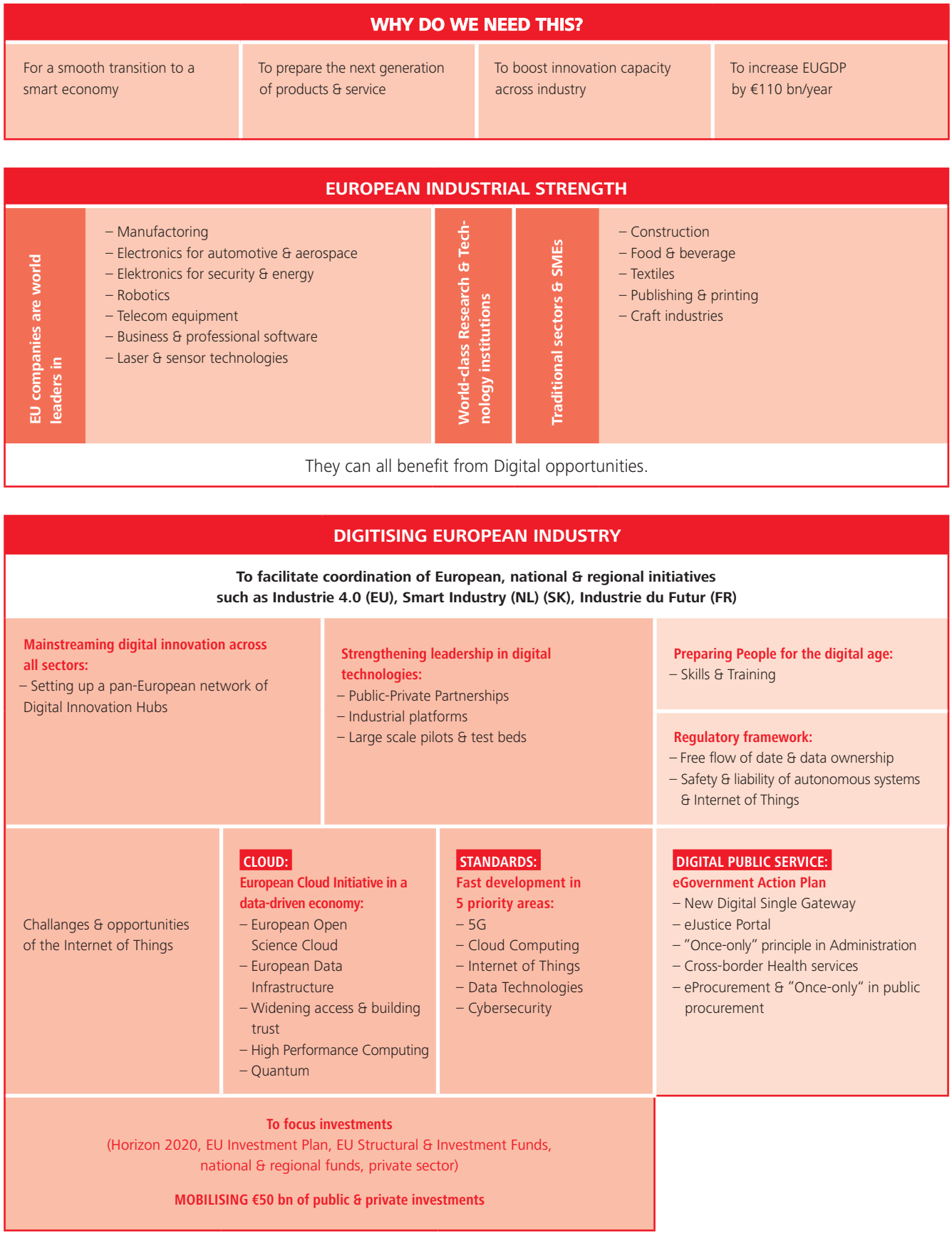
With regards to digitalisation, Europe still faces considerable challenges, also in view of Industry 4.0. One can observe quite favourable initial conditions in several member states, but considering the low level of investment by SMEs in information and communication technologies (ICT), and the need for standardisation (frictionless data flow between sectors and regions) and regulatory measures (on data, liability of systems, security issues etc.) that can only be solved on the European level, it clear that more political action is required. The declared goal of the Commission is to "... promote the competitiveness of the EU in the area of digital technologies and to ensure that all companies in Europe, regardless of sector, location and size, are able to take full advantage of digital innovations" (European Commission 2016: 7). Subsequently, the Commission is pursuing three central objectives: (1) the strengthening of political coordination, (2) investments in the capacity for innovation and (3) the development of skills.

3.4.1 STRENGTHENING COORDINATION BETWEEN COMMISSION, MEMBER STATES AND STAKEHOLDERS

In the recent past several national and regional initiatives have been launched to promote the digitalisation of industry. To avoid the danger of further fragmentation of these initiatives, the Commission aims to bundle the necessary public resources, sending a clear signal to private investors.

If efforts remain solely on the national level, this could lead to a subcritical deployment of resources and a lack of sufficient private investment. Europe provides a clear added value. Likewise, sharing of experiences about best practices is an advantage with regards to building skills and qualification. In order to strengthen coordination between the European and national levels, the Commission plans to hold two "high-level round tables" per year to ensure an ongoing discussion throughout

Figure 5
Digital Single Market



Source: European Commission 2016.

the EU; an annual European forum with (broad) participation of actors from the entire digital supply chain; regular reports on national and regional initiatives and priorities. The first such meeting took place in Essen in late January 2017. There, the European Commission and Germany organised the first stakeholder forum under the slogan "Digitising European Industry".

3.4.2 STRENGTHENING CAPACITY FOR DIGITAL INNOVATION

Establishment of Digital Innovation Hubs across Europe
Excellent research-focused universities and public research institutes should be developed into Digital Innovation Hubs (DIHs), enabling industry to experiment with and test digital innovations. This is intended to lower the investment risk for SMEs in particular and to strengthen the benefit of simulation. Besides the testing of the applicability of digital technologies, the DIHs should facilitate access to financial resources and provide public relations services. The long-term goal is to build up a European network of DIHs, which serve as one-stop shops for SMEs to access modern digital technologies. To finance the initiative, resources from the Structural and Investment Fund as well as the European Fund for Strategic Investments (EFSI) are available. Furthermore, the Commission plans to invest €500 million from Horizon 2020 in DIHs.

Development and establishment of public-private partnerships
Due to the large-scale investment that must be made in high-performance equipment and data infrastructure, the European Commission believes that public-private partnerships present an opportunity to mobilise private resources. Furthermore, PPPs can facilitate the coordination of fragmented R&D efforts in the member states and drive the establishment of norms and standards. Although their effectiveness is still disputed (Weimar/Vining 2017: 319), according to the Commission's plans, PPPs should receive stronger support so that they "become a real aggregate framework and ecosystems for digital industrial innovations" (European Commission 2016: 11). In the coming five years the Commission plans, within the framework of Horizon 2020, to spend approximately €5 billion on supporting the strategic research and innovation plans of PPPs, which should be complemented by a further €15 billion in spending by industry. In addition, roughly €15 billion could be added to that sum via member state funds, EFSI and ESIF.

Apart from these PPPs, whose primary goal is the development and implementation of their own research plans, the Commission is planning cross-sector, integrated digital platforms, which are to be developed with the support of their reference architectures – as well as their step-by-step realisation, testing and validation in self-developing ecosystems. A group of platforms seeks to integrate digital technologies such as the Internet of Things, Big Data and Cloud-Computing, Autonomous Systems and Artificial Intelligence. To these belong the initiatives on "the leading role in the Internet of Things (IoT)", in which large-scale pilot projects and "beacon" initiatives are to be supported, as well as data platforms such as the PPP on Big Data, which alone has been allocated €2.7 billion in private and public funds.

A second group serves to develop industry-specific platforms. These include, for example, initiatives such as one for the "networked intelligent factory. The PPP "Factories of the Future" was established already in 2008. These industry-led stakeholder forums develop their own measures and road maps for research and innovation activities. The goal is to bring together relevant actors around a societal challenge (mission orientation) and to achieve a leverage effect for private capital via the application of public funds. A driver of this funding policy was the "European Factories of the Future Research Association" (EFFRA), which to these purposes developed the European Technology Platform (ETP) MANUFTURE. In accordance with European allocation rules, the goal of EFFRA is to promote pre-competitive research.

PPPs are funded over the Framework Programmes for Research and Technological Development (FP7, Horizon 2020). The research priorities are set through public consultations and laid down in the form of multi-year road maps. The integration of industry is supposed to ensure that the research activities are oriented towards introduction on the market. Within the framework of the "Industrial Leadership" segment of Horizon 2020, €278 million were allocated for research and innovation projects in the area of Advanced Manufacturing (European Commission 2014a; European Commission 2014).

Standardisation
For both the development and the dissemination of new products, services and processes, standards play a considerable role. They result in better-functioning, more compatible products and safeguard consumer protection. They facilitate product development, shorten the time to market readiness and secure the compatibility and interoperability between different sectors of industry, so that further products and services can be developed (European Patent Office 2017). Against the backdrop of growing digitalisation and globalisation, international standards help dismantle trade barriers and foster global trade. Here, in particular, a single (digital) interior market could show its strengths – a lead market with enormous economic clout that would be well-positioned to drive standardisation forward worldwide, also in areas such as data protection and data security.

The Commission has also recognised the importance of the topic and is keen to focus its efforts on the areas which are relevant to Industry 4.0 and disseminate them which regards to reference architectures and testing. The goal is to first become strategically focussed and then develop a suitably robust mechanism for the realisation process. In view of the strategic orientation of standardisation, the Commission identifies five areas that should be central to these efforts: 5G, Cloud Computing, Internet of Things, Data Technology and Cybersecurity. The realisation mechanisms comprise regular monitoring, a continued political dialogue with relevant actors, and intensive cooperation with national and international standardisation institutions.

Future and Emerging Technologies (FET)
The FET programme is shaped by DG CONNECT in cooperation with other Directorate Generals. As a part of the "Excellent Science" strand within Horizon 2020, these funding activities are directed towards universities and research facilities as well as high-tech companies, which should be given an incentive

to implement radical new technologies. This area of the programme resides over a total budget of roughly €2.6 billion (European Commission n.d.). The FET programme is divided into three parts, none of which explicitly target Industry 4.0 activities, but which play a significant role due to the implicit focus on information technologies.

- FET Open aims to support visionary open-topic ideas in science and technology in the early stage. Forty percent of the budget is earmarked for this line of funding. Thanks to the simplified application process and the lack of topical restrictions, FET Open presents an attractive opportunity to participate in EU research funding for new actors, as well as for research-intense companies and young research groups with an interdisciplinary focus.
- FET Proactive supports promising new technologies and their interdisciplinary research communities. Larger consortia, however, investigate the technological possibilities and societal effects of specific research topics specified in the work programme. Additionally, the activities of the "High Performance Computing" public-private partnership receive funding within the framework of FET Proactive programme.
- The FET flagships "Human Brain" and "Graphene" are large-scale, science-driven research initiatives with an estimated duration of 10 years and a total budget of €1 billion. The aim is to bring Europe to the forefront when it comes to finding solutions to central scientific-technological challenges.

3.4.3 DEVELOPMENT OF SKILLS

In the course of ongoing digitalisation, the nature of industrial work will change fundamentally. Nevertheless, it is currently hard to predict which consequences this transformation will have for social and labour market policy. The potential challenges require a commitment by the member states to invest in the development of skills. In this question the Commission has little room for manoeuvre since control of educational policy clearly lies in the hands of the member states. In the course of the digitalisation of industry, the Commission is therefore planning a long-term structured dialogue between the relevant stakeholders about the social aspects of digitalisation. Industry itself plays an important role in the identification and transference of key qualifications and skills.

While this is a challenge for all of Europe, the member states and regions continue to be responsible for the most important of these competences. The specific issues must be explored and addressed on the national and regional levels. Moreover, the additional training and retraining of workers must take place within the companies themselves which requires substantial participation by firms and social partners alike, a process where till now we have seen significant divergence between, for example, ((meso-)corporatist) states like Sweden and Denmark, Germany and Austria, and countries such as Britain, Spain and Italy.

Commission initiatives such as the "Grand Coalition for Digital Jobs", launched in 2013, can be suitable means to generate interest in the topic and obtain commitments from actors for measures on continued education and training. This could act as a blueprint for the aspiring "New Skills Agenda for Europe".

There are also plans to connect the aforementioned Digital Innovation Hubs with educational facilities resulting in the creation of suitable training and re-training opportunities at a local level. Such initiatives would link into existing strategies for Smart Specialization and support the continued development of Triple-Helix systems into Quadruple-Helix systems.

3.5 INDUSTRY 4.0 IN THE EUROPEAN POLITICAL ARENA

In sum, the European Commission, with its innovation policy programmes, appears to be pursuing a lead market strategy for Industry 4.0 which is bundled first and foremost in the "Digital Single Market Strategy". A lead market can be defined as a geographically delineated market which fosters global innovation through favourable local preferences and framework conditions (Klodt 2011): price and cost advantages, transfer, diffusion and export advantages, high income elasticity regarding the demand for innovations and an advantageous market structure (competition). Precisely this emphasis on the demand side represents a significant evolution of innovation policy. A first step in this direction was taken with the so-called Aho-Report (Aho 2006), whose recommendations the Commission is currently attempting to realise in its measures: for example, via "innovation-promoting" awards and grant practices, the reduction of bureaucracy, and supporting the establishment of centralised norms and standards on the European level (e.g. in the Digital Single Market or through the Innovation Union) and the development of regional ecosystems (e.g. through European Innovation Partnerships – EIP), which are primarily intended to support small and medium-sized enterprises in the area of digitalisation and internationalisation. Furthermore, efforts are being made to use funds from the European Investment Bank and the European Investment Fund specifically for these purposes, as is underscored by the current "Investment Offensive", or the so-called Juncker Plan (Buhr 2016).

Beyond this, the EU is trying, with the help of a working group and the industry initiative EFFRA, to support cooperation between national research initiatives in the field of "Digital Manufacturing" (Ittermann et al. 2015). In the area of European research funding the topic of Industry 4.0 is embedded in "European transnational production research" (ERANET-MANUNET) as well as in the benchmark project INBENZHAP[2]. Furthermore, various lines of funding that address the topic can be found within Horizon 2020. Especially for countries whose research budgets have come under pressure through crisis management and strict austerity policies, EU research funding now usually represents the most important source of financing.

Responsibilities within the innovation policies for Industry 4.0 are not just distributed between the European Union and the individual member states, but also within the different

2 cf. the project "Industry 4.0 – International Benchmark, Future Options and Recommendations for Actions in Production Research (INBENZHAP)". The aim of this research project was to develop options for the design of industrial production in Germany and discover thematic areas in which possibilities for a pioneering role exist for Germany (cf. http://www.acatech.de/?id=2352).

levels within various Directorate Generals and ministries. This makes efficient coordination of this interdisciplinary policy area considerably more difficult (Buhr 2010; 2015). This is not particularly surprising within a multi-tiered system. This results from the dispersion of competences among organisations defined by territory. While competences are distributed over different levels, the responsibilities are interdependent and enmeshed in various institutional systems. Applied to innovation policy this means that we find many very different logics among the central actors. The most commonly stated rationale for state involvement on the national level is (international) competitiveness. It is hoped that public investments in both the scientific-technical infrastructure as well as in research and development in the fields of so-called key technologies, coordination of relevant private and public actors and the improvement of general conditions will create a positive climate for innovation. However, certainly not all regions can be transformed into high-tech clusters. Therefore the supra-national, European level must play an additional role: the promotion of competition must be accompanied by compensation. This is what differentiates it from many other political actors involved in innovation policy, especially those on the subnational level. The efforts of the latter, in line with the logic of CRA (Constructed Regional Advantage), aim to exploit competitive advantages or as Asheim et al. (2011) write: "CRA means turning comparative advantage into competitive advantage through an explicit policy push" (Asheim et al. 2011: 1.133). Here, regional structural policy, which is bound to the principle of the welfare state and focused on compensation, collides directly with a technology-focused innovation policy, which is geared towards key industries of the respective national production and innovation system (Rehfeld 2014).

3.6 INTERIM CONCLUSION: COMPETITION, COHERENCE AND COHESION

Thus, in the area of Industry 4.0, European innovation policy again finds itself in the contentious field of competition, coherence and cohesion. One suspects that especially those member states that have played a pioneering role in the field (e. g. Germany, Sweden) could direct most of their attention towards national funding programmes and therefore take a more sceptical position towards European measures. Meanwhile, in the era of austerity policy other member states rely almost entirely upon European funds to conduct their innovation policy, most likely in the form of a (totally relevant) research policy. On the one hand, one can assume that – according to the logic of competition – the pioneers are unlikely to reduce their own engagement because of European funding practice nor open it up to participation by other member states. On the other hand, it seems prudent to work together even more intensively across Europe, especially in the areas of standardisation and norms as well as data protection and data security. Therefore, it would be advisable to develop systemic solutions in European networks in order to be able to occupy an even stronger position on the world stage.

Competition and the targeted funding of those locations that have already assumed a leading role in the field of Industry 4.0 within European innovation policy is destined to conflict with the objective of cohesion (Buhr 2016). Now as before, the European Union has failed to significantly close the gap between the divergent performances of member states, as evidenced by the Innovation Union Scoreboard (European Commission 2017).

Figure 6
Estimated investment in the digitalisation of European industry

2016/2020	EU (ongoing or planned)	Member states	Industry
Digital Innovation Hubs	€500 million (from Horizon 2020)	€5 billion (ESIF, regional budgets)	ca. €17 billion
Public-Private- Partnerships	ca. €4 billion (from Horizon 2020)	nearly €1 billion (contribution for "Electronic Components and Systems for European Leadership (ECSEL) Partnership")	
National policies/ digitalisation strategies		€15 billion (planned national digitalisation programmes)	
Important Project of Common European Interest (IPCEI) on Electronics – planned	€300 million contribution for the Electronic Components and Systems for European Leadership (ECSEL) Partnership	€1 billion from member states (e.g. France, Germany, Netherlands, Italy and Britain)	€5 billion
European Cloud Initiative	ca. €2 billion from Horizon 2020 are being invested into the European Cloud Initiative	€4.7 billion in additional resources from private and public sources for European data infrastructure	

Source: European Commission 2016.

4

THE NATIONAL LEVEL

At first glance the national strategies for digitalisation in general as well as specifically for Industry 4.0 do not appear to be particularly coherent. The initial situation of each EU member country and specific local needs diverge from one another considerably, although one can ascertain that virtually every EU country has implemented measures to foster Industry 4.0, as is made clear in Figure 7.

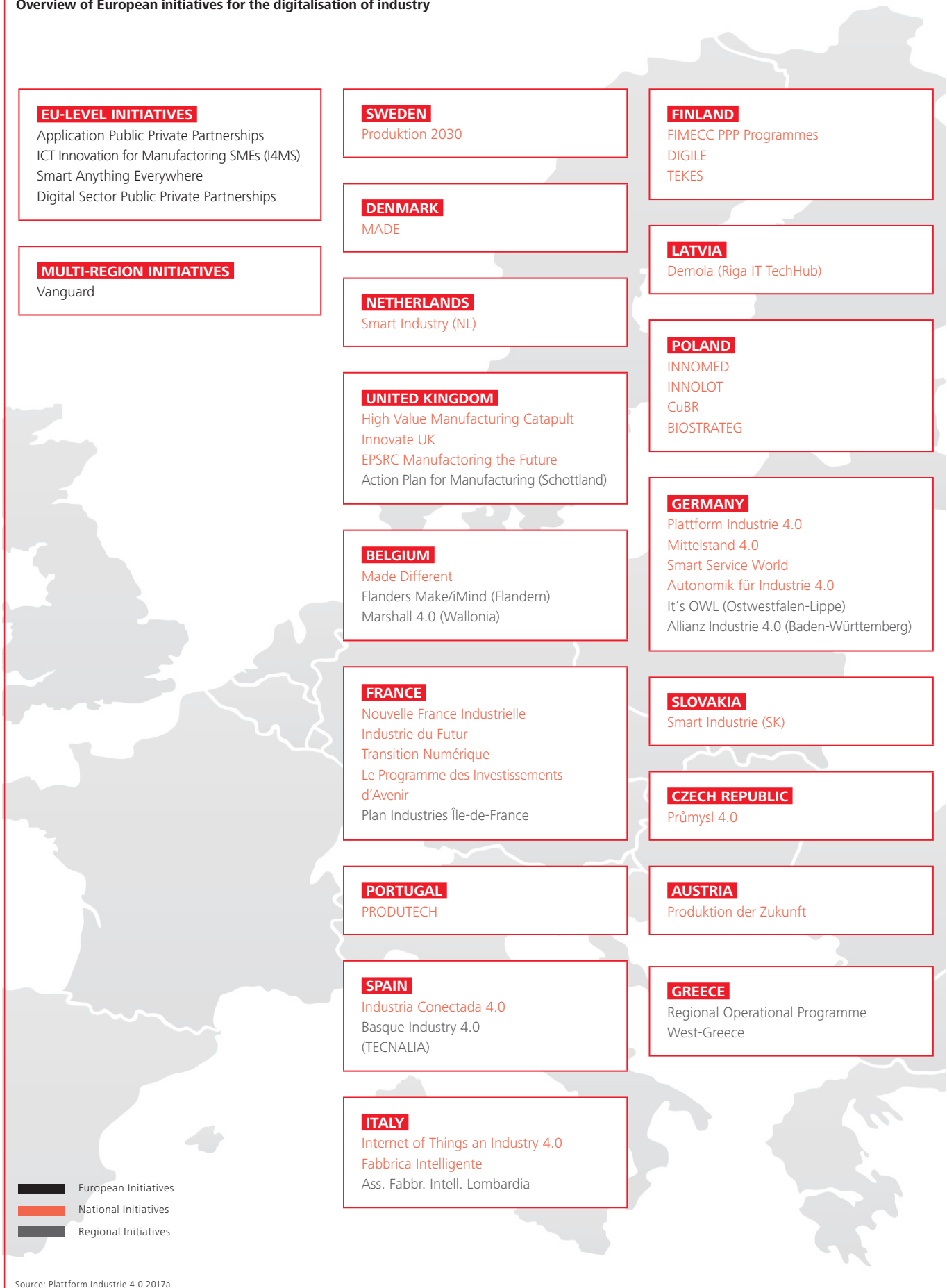
Following David Ricardo (comparative advantage), the literature on competitiveness (e.g. Asheim et al. 2011) or comparative research on capitalism (e.g. Hall/Soskice 2001), the respective institutional structures (e.g. norms, regulations, routines) have developed different ways to deal with the respective challenges (in this case, digitalisation). These ways have an effect on national (innovation) policy. Here we can distinguish between very close, direct state influence on the economy (e. g. as proprietor, financier, etc.) and a rather more distanced influence (e.g. as regulator) (Hancké et al. 2007), also in regards to organisation (fragmented/structured) and the integration of interest groups (strong/weak). This appears to have consequences for the form of innovation policy towards Industry 4.0, which we will consequently present with the examples of Germany, Britain, France and Italy.

4.1 THE NATIONAL LEVEL – THE EXAMPLE OF GERMANY

With the High-Tech Initiative in 2006, the Federal Government presented, for the first time, a medium-term strategy with concrete objectives which was intended to deliver an integral innovation policy. This remains recognisable in the successor programme, the High-Tech Strategy 2020. Here, too, Industry 4.0 is named among various projects of the future. Its aim is the long-term establishment of Germany as a leading supplier and production location for digital equipment, processes and products (Ittermann et al. 2015). As a consequence, the Federal Government launched a series of technology-centred research programmes in order to promote the "technological leadership" of German industry: e.g. "Autonomics for Industry 4.0" (€40 million from the BMWi, Federal Ministry for Economic Affairs and Energy) or diverse BMBF (Federal Ministry for Education and Research) programmes under the title "Industry 4.0 – Innovations for the production of tomorrow" (funds totalling around €120 million). A further focus of the BMBF's Industry 4.0 research is "Intelligent Technical Systems OstWestfalenLippe (it's OWL)", a cluster of excellence where the cooperation of (medium-sized) technological leaders and research facilities for the development of a new technology platform has been funded since 2012 on the regional level. These initiatives are framed by the Federal Government's "Digital Agenda 2014-2017" which, as a cross-departmental strategy for the various aspects of digitalisation – from the installation of broadband through digitalisation of the workplace to the topics of IT security and Industry 4.0 (cf. BMBF 2014; BMWi 2014). Furthermore, various model factories, centres of excellence and corporate projects are supported by federal states across the country, e. g. Baden-Württemberg, Berlin, North Rhine-Westphalia, Rhineland-Palatinate, which are working on the development of production technologies and their operational application.

The Federal Government was early to seize upon the rapid societal and technological developments in this area and laid down structures for the cooperation of central actors in the innovation process in Germany, initially with a strong focus on technical development. Since then, a number of these initiatives, very much in line with the lead market concept and proven meso-corporatist logic, have been bundled in the so-called "Plattform Industrie 4.0". The Economics Ministry (BMWi) and Research Ministry (BMBF) monitor and manage the platform together with high-ranking representatives from business, science and labour unions. Experts working in topic-centred groups are tasked with developing operative approaches to solving problems in the areas of standardisation and norms, security of networked systems, legal frameworks, research and the organisation of work. The steering committee of business representatives develops a strategy for the technical realisation of the working groups' results. The strategy committee, consisting of representatives from politics, industry groups, science, labour unions, federal departments and the federal states are responsible for the political management and function as multipliers in the societal discussion of the effects of Industry 4.0. The starting point of the platform was the Industrie 4.0 working group established by the BMBF's R&D Advisory Council

Figure 7
Overview of European initiatives for the digitalisation of industry



Source: Plattform Industrie 4.0 2017a.

Economics & Science. By October 2012, the working group had presented "Recommended actions for the future project Industrie 4.0". The industry groups Bitkom, VDMA and ZVEI were the first to act on the call to continue and develop the Industrie 4.0 project. In April 2013, they shaped an agreement on an ideational cooperation to run Industrie 4.0 as an inter-organisational platform. In April 2015 Industrie 4.0 was expanded to include additional actors from business, industry associations, labour unions, science and politics.[3]

4.2 THE NATIONAL LEVEL – THE EXAMPLE OF BRITAIN

The discussion surrounding Industry 4.0 in Britain (and in the USA) usually occurs under the banner "Advanced Manufacturing". The British innovation funding agency Innovate UK (previously known as the Technology Strategy Board) presented in 2012 the "High Value Manufacturing (HVM) Strategy 2012-215", in which recommendations included the financial support of technology development in manufacturing and combining this with high-growth industries such as transport, advanced materials, energy and biotech. Due to traditional manufacturing's relative loss of importance in Britain, Innovate UK is placing a greater focus on funding research-intensive, high-growth industries in the phase up until 2020.

Here, a central component was the development of "HVM Catapult Centres". The Catapult programme was announced by the British government in 2010 in order to close the gap between applied research and commercialisation. The Catapult programme also serves to create a more balanced economy, in as far as it supports the industrial sector alongside the service sector. In terms of their objectives, Catapult Centres can be compared to the Fraunhofer Institutes, in that they perform market-oriented research (typically in the area of Technology Readiness) and in that their financial resources consist of state funding, private R&D contracts and collaborative British and European research projects.

The HVM Catapult programme comprises seven industry-oriented research centres and offers companies access to research facilities in order to scale up and test high-quality production processes. The long-term objective is to increase the share of the manufacturing sector in the British economy. At first glance, digitalisation of industry does not appear to play a role. The strategy, it seems, is oriented instead towards strengthening and maintaining existing competitive branches of industry.

A significant component of the funding landscape in Britain are the so-called Research Councils. In the area of industry, the "Engineering and Physical Sciences Research Council (EPSRC)", which oversees the funding focus "Manufacturing the Future", plays an important role (EPSRC 2017). In the current funding period, £470.51 million is being spent via the programme lines. Britain is home to internationally competitive manufacturing industries such as aerospace, pharma, electronics and photonics. The EPSRC plays an important role in supporting these industries and makes possible modern research and the education of highly-qualified scientists working to support British innovation in production technologies. The research funding includes basic research in the areas of simulation and design, production, manufacturing, systems and services. This funding continues until the technology stage, after which applications can be further developed by companies or agencies such as Innovate UK and the Catapult network.

4.3 THE NATIONAL LEVEL – THE EXAMPLE OF FRANCE

French industry has struggled with a deep crisis of competitiveness over recent years. To tackle the crisis, the French central state launched the programme known as "The new industrial France" (Nouvelle France Industrielle, NFI) in September 2013 (Le gouvernement français 2013). In order to integrate several relevant political actors into this programme, the so-called "Alliance for the industry of the future" was announced in the following year, an alliance consisting of companies, engineering science universities, professional and research organisations as well as the national industrial council (CNI). The aim is to work together on projects and systemic solutions on re-structuring the French industrial model through digitalisation. NFI is organised into five pillars:

- Development of future technologies;
- Support of companies in the transition phase;
- Training of staff;
- Public relations work;
- Strengthening of European and worldwide cooperation.

From 2013 until the end of 2015 around €1.9 billion of public funds were allocated (Le gouvernement français 2013), primarily within the framework of the funding focus on the development of future technologies. This is divided into seven fields of activity:

- Digitalisation, virtualisation and the Internet of Things;
- The human in the production facility, robotics and augmented reality
- Additive manufacturing (3-D printing);
- Monitoring and control;
- Composite materials, new materials and montage;
- Automatics and robotics;
- Energy efficiency.

Besides the development of future technologies, the second pillar ("Support of companies in the transition phase") is also interesting and characteristic of the French system of regional compensation. Here SMEs are individually supported in processes of modernisation and reorganisation. All regions now reside over funding programmes which make possible evaluation of business models by experts and the possible realignment of business models in light of digitalisation. Up to €719 million have be earmarked for this programme (Le gouvernement français 2013).

Fundamentally, French companies have good access to ITC, but they only use it to a limited extent. At the end of 2013, 99 percent of companies had broadband access, but only 64 percent of them had a website (95 percent in Sweden, 74 percent in the EU28), and just 25 percent of them sold

3 cf. Plattform Industrie 4.0 at http://www.plattform-i40.de (16.7.2016).

goods and services electronically (as opposed to 51 percent in Britain, 38 percent in the EU28) (DGE 2015).

The "Digital Transition" programme ("Le Programme Transition Numérique) (République Française/DGE 2912) launched by the government in 2012 aims to support SMEs in both the acquisition of digital applications and the integration of these technologies in production in order to improve competitiveness. Funding goes towards the deployment of consultants (Conseillers au Numérique) who can inform SMEs about best practices in the use of digital technologies. The placement of consultants occurs through the regional chambers of industry and commerce, tourism agencies or craft chambers.

4.4 THE NATIONAL LEVEL – THE EXAMPLE OF ITALY

Most of Italy's manufacturing industry is located in the north of the country, resulting in large regional differences with respect to industrial competitiveness when compared to the south. The regional differences are made even more stark by the fact that broadband is mainly concentrated in the northern regions and that the large companies eager to invest are mostly found in the northern regions. It is therefore no surprise that the most significant initiatives in the private sector regarding Industry 4.0 originate in the northern regions such as Lombardy (for more, see the "Lombardy Intelligent Factory Association")[4].

In light of the fact that very few large ITC-relevant companies exist in Italy and that Italian industry is primarily made up of SMUs, the Ministry for Economic Development presented a strategy for coordinating Industry 4.0 funding. Plans were made for a multi-stakeholder forum not unlike Germany's Plattform Industrie 4.0, made up of representatives of the relevant ministries, leading universities, research centres, business associations and labour unions. The platform's objective is to activate and accompany the transformation process. The main political-strategic features are outlined in a "National Industry 4.0 Plan 2017-2020" ("Piano nazionale Industria 4.0 2017-2020") (Ministero dello sviluppo economico 2017). The national plan consists of four strategic points:

- Investment in innovation: Stimulation of private investment in the introduction of technologies, Industry 4.0 and increased spending on research, development and innovation;
- Improvement of infrastructure: Provision of a sufficient network infrastructure, ensuring data security and data protection, cooperation in the establishment of international interoperability standards;
- Education and research: Building skills through training and developing research funding;
- Awareness and governance: expansion of knowledge in the potential applicability of Industry 4.0 technologies and ensuring that stated objectives are reached with the support of private-public governance.

The most interesting aspect about investment funding in Italy when compared to Germany is the funding that occurs through tax incentives and amortisation possibilities. Companies can take advantage of a mechanism of increased amortisation in connection to investments in technologies relevant to Industry 4.0[5] (purchase value increased by +250 percent). Beyond that, the possibilities of tax credits for research, development and innovation expenditures have been boosted (increase of the credit for intramural expenses from 25 to 50 percent, expansion of the ceiling amount from €5 million to €20 million). Similar incentives have been designed especially for innovative start-ups in order to absorb the financing difficulties during the founding phase (Ministero dello sviluppo economico o.J.).

4.5 INTERIM CONCLUSION: THE LACK OF SHARED VISION

In the four counties examined, we see different strategy directions with respect to Industry 4.0 as well as in the respective state innovation policies. In Britain the topic is seen primarily through the aspect of re-industrialisation. There, innovation policy is shaped centrally in London. By contrast, in Italy the regional level plays a more significant role with regards to the substantial developmental differences between northern and southern Italy. France, more than any other country, is banking on a European solution when it comes to the realisation of the national development strategy and is hoping for direct exchange with Germany.

Italy's innovation system is characterised by low R&D expenditures in the private sector and the need to increase innovation performance. The inadequate interaction between universities and companies is a central challenge for state innovation policy. One must add to that the persistent structural problems of the Italian innovation system with regard to the deep regional inequalities, that also apply to the broader economic and social structure. On the one hand, the SMEs in northern Italy which export worldwide form the backbone of the Italian economy. On the other hand, they are setting the course for national developments in the area of Industry 4.0 – which exacerbates the disparities between the north and south of the country. To that effect Industry 4.0 and applied research in general is driven primarily by regional industrial associations. The competences required for the realisation of Industry 4.0 solutions are available thanks to progress in the area of automation and a high degree of specialisation. Since 2015, the Italian government has presented a series of measures to stay abreast of these challenges. It is, however, not possible to make conclusions about their success.

The British research system, by opposition, is to a large degree centralised, although regional autonomy has increased in recent years with regards to innovation policy. Most of the research funding across Britain comes via the Research Councils, which have a nationwide mission. The central challenges for the British innovation system are currently the need for increased public and private investment in R&D, the commercialisation of the results of public R&D, support of start-ups and scale-ups as well as provision of sufficiently well-trained staff.

4 cf. http://www.afil.it/en/.

5 Advanced manufacturing solutions (e.g. robots); additive manufacturing; augmented reality; simulation; horizontal and vertical integration; industry-internet; cloud; cybersecurity and big data.

Britain has presented a comprehensive re-industrialisation strategy. There is a great need for technological catch-up due to the decades-long neglect of manufacturing. Productive industry pales in comparison to the financial sector. Now, by including the digital economy, attempts are being made to strengthen the industrial sector. The strong start-up scene in London is slowly being supplemented by the technology-intensive manufacturing industry, which is focused primarily on radical innovations.

In France, too, the importance of industry has waned in the last few decades (de-industrialisation). The government is attempting, through the "Nouvelle France" strategy, to stop the decline of French manufacturing. Industry should receive support in adapting to new paradigms such as cloud computing. France has introduced a number of political instruments and public organisations to foster innovation. However, there appears to be a disparity between the number of instruments and their cost and the actual results. Despite several reforms, the overall system is still overly complex and in need of simplification. The French research scene is traditionally dominated by large public research facilities. Their performance is being increasingly seen as a limiting factor, since the reforms for increasing quality have had only a limited effect on their scientific output.

The differences presented above reflect the approach of the European Commission, in that it mostly leaves it up to the member states to create suitable funding programmes and strategies for the realisation of Industry 4.0 or to increase local competitiveness in general. The Commission has no instrument at its disposal which can be used to harmonise national efforts. Nor does it aspire to establish such an instrument. This makes two things very clear: first, it can be considered positive that the Commission prefers bottom-up solutions (of any kind whatsoever) and that it has not presented a EU-wide development plan for Industry 4.0. Second, it lays bare insufficient controllability in Brussels with respect to innovation policy. A political field as complex as innovation policy with all of its aspects, from competition policy (where the Commission has a greater say) to educational policy (where it has no say), is simply difficult to control.

One can also surmise that it could be very difficult to create equal conditions for the realisation of Industry 4.0 in the more developed and less developed EU member states with the instruments the Commission currently has at its disposal. With a policy that is primarily focused on austerity, and without massive outside support, it is difficult, especially for the poorer member states, to create these conditions (investment in digital infrastructure, education and training, modernisation of the welfare state etc.). If the EU is to be a project of international solidarity as well as shared economic and social progress, the advantages of digitalisation cannot remain restricted to a handful of regions or nation-states but must be systematically supported across the EU (Alaja et al. 2016).

In the current situation, there seems to be no shared vision on the topic of Industry 4.0. While the potential has been highlighted in many studies (by business consultants), at the moment there is a wide gulf between the aspirations and the reality. If the Commission fails to present a vision and a strategy to support the poorer member states, we can expect even greater economic disparity thanks to the huge gains in productivity expected in the richer member states.

5

ANALYSIS AND RECOMMENDED ACTIONS

In can be concluded that the European level plays a very important role in the area of Industry 4.0. However, the limitations of EU policy become clear. Due to the fact that the promotion of Industry 4.0 is an inter-organisational task, the participation of several Directorate Generals is necessary. This fragmentation is amplified by the multi-level system of the EU, which makes both vertical and horizontal coordination enormously difficult.

Therefore, the EU – despite the diverse forms of funding, especially in the framework of its research policy in Horizon 2020 – has a limited capacity to present a holistic concept to fund Industry 4.0, resulting in great missed opportunities when it comes to innovation policy. Here it is noticeable that, despite all of the rhetoric, innovation policy simply does not enjoy the same prioritisation as, for example, energy policy. Even in the newly formed Juncker-Commission, there is no project team lead by a Vice President that concerns itself with innovation in a concentrated and coordinated way. "Innovation" remains primarily the concern of the Research Commissioner (Carlos Moedas) (Reillon 2016), who surprisingly only holds the status of an associate member in the project teams on "Jobs, Growth, Investment and Competitiveness" (VP Jyki Katainen) and the "Digital Single Market" (VP Andrus Ansip). The overarching coordination remains rather murky, even if Commissioner Moedas did at least present the follow-up agenda for the Innovation Union in June 2015. Apart from rather symbolic actions – the responsible department in the DG Research and Innovation was, for example, renamed "Open Innovation" – the agenda also contains recommendations for a "European Innovation Council". Commissioner Moedas triggered a public debate on the subject and the public consultations were completed in 2016. Currently, we are in the midst of a political negotiation process on if and when the EIC should be established. What is certain is that it should support disruptive innovations and ease access to financing opportunities (especially venture capital).

Such a coordinating body would be helpful, on the one hand, when it comes to improving the horizontal coordination over several Directorate Generals and, on the other hand, pushing vertical coordination (over regional policy, for example). Here, there is plenty of work to be done on the European level: issues of data protection and data security, of data availability and data interoperability need to be clarified as well as questions related to the organisation of work and qualification – and how new services and successful business models can be developed.

A promising approach appears to be the funding of large field tests in real living-lab settings and pilot projects to examine concrete questions during ongoing operation and through "learning by using", and to test new service concepts for their feasibility and acceptance. This is also important for the fostering of social innovation. Additionally, the EU could be asked to set generally recognised standards and create the corresponding regulatory framework. At the moment, neither the EU nor the German government nor the German federal states are in a position to present a holistic concept for the promotion of Industry 4.0, not to speak of coordination of the various measures. Many initiatives operate parallel to one another and in competition with one another. One attempt to alter this can be found in the German "Plattform Industrie 4.0" initiative. However, this initiative still needs to prove its success – e.g. through the development of joint business models, platforms and technical standards. It should also make an effort to include workers and users in the innovation process.

5.1 RECOMMENDATIONS: MORE INNOVATION, MORE EUROPE, MORE COORDINATION

5.1.1 MORE (SOCIAL) INNOVATION

In the era of Brexit and migration, the financial crisis, austerity policy and growing nationalist and populist forces in many parts of Europe, innovations are of vital importance. We will be unable to tackle the great economic, societal and social challenges of the future without technical and social innovation. Herein lie the great opportunities of Industry 4.0: in the future, industrial processes could become cheaper, more resource-conserving and more efficient. Industry 4.0 also offers enormous potential for new products, services and solutions, which could enrich people's daily lives. Digital networking makes possible

the direct integration of customer wishes and employees' ideas as well as the affordable customisation of products and services.

The starting point for a successful innovation is the human being, his or her needs and environment. Such an innovation must not necessarily always be based upon a new technical development. Technical innovations stimulate social innovations – and vice versa.

New technologies and techniques are created precisely because new organisational forms arise and new social practices become routine. And so technical and social innovations are tightly enmeshed, especially in the area of digitalisation: Web 2.0, e-commerce and so-called prosumers who participate in product development are just a few examples. Such developments should also receive more consideration with regards to Industry 4.0 (Buhr 2015).

Therefore, the European Union and its member states should use digitalisation to modernise the welfare state (Buhr et al. 2016). Greater integration of innovation policy with social policy is desirable: what, for example, can digitalisation do in order to achieve inclusive growth? The workplace could, for example, be designed to be more humane. The latter point shows that state action is indeed called for (see Weißbuch Arbeit 4.0, Federal Ministry of Labour and Social Affairs). On the European level innovation policy belongs high on the agenda. Innovation policy is more than pure industrial policy. Therefore, in future, the ESF, the Cohesion Fund and the EFSI should be used more intensively to fund digitalisation and innovation projects. Innovation policy should strengthen not only the economy and science but also take societal and social progress into consideration.

5.1.2 MORE EUROPE

The European Commission should become more aware of its importance and assume a leading role in innovation policy – beyond the "Digital Single Market", and when it comes to topics such as data protection and data security (e. g. "European cloud infrastructures", Single Digital Market and European legal frameworks) as well as the strengthening of Europe as a location for science. Here it is noticeable that, for example, Horizon 2020 is more focused on actors in business than previous framework programmes for research. At first glance, this is to be welcomed since knowledge is often created as practical knowledge, through "learning by doing" and "learning by using". People are the carriers of this knowledge and the drivers of innovation, meaning education, training and qualification gain in importance. However, this does not make basic scientific research obsolete. On the contrary: precisely the states that lead the Innovation Readiness Index (Sweden, Denmark, Finland) are characterised by a very good, broad (public) science system.

The following should receive even more support in the future: the (international) mobility of scientists and inventors, the exchange of personnel in science and business, as well as openness, networked thinking and creativity (Buhr 2015). If the objective of cohesion is to be taken seriously, the EU must manage to provide balanced funding, so that the smaller states can keep up.

The great added value of EU funding results, finally, from the fact that funding goes towards research activities that single companies or member states would otherwise not carry out alone. The platforms and PPPs mentioned above serve primarily the sharing of information and experiences. Evaluations of the mechanisms and direction of these policies have been very limited to date – but this should change soon.

Over the past few years, the pace of digitalisation has been determined primarily by a few companies in Silicon Valley which also dominate the global stock markets. Their business models are sometimes disruptive but often only incrementally so: their revenue is based on proceeds from advertising. Europe also has plenty to offer. The continent continues to be a strong centre of industry with developed welfare states and a large market. Almost 800 million people live here – the 28 European Union member states alone are home to half a billion inhabitants. Furthermore, Europe enjoys good relations to other important industrial countries such as South Korea, Japan and China, relationships which should be intensified in the future (also in the sense of standardisation and norms).

Based on the analysis of existing studies as well as our own observations, but also the virtually consensual statements heard during all of our interviews, one can clearly conclude that, more than anything, European innovation policy lacks strategic direction. A mission orientation modelled on the United States' Defense Advanced Research Projects Agency (DARPA) or in the sense of the "Entrepreneurial State" (Mazzucato 2015) could not be identified. Furthermore, the focus on funding purely technological developments allows us to conclude that important aspects such as skills acquisition (education and training) and the development of business models still require considerable funding. Therefore, it seems advisable to orient European innovation policy even more towards societal challenges while integrating the societal actors closely into innovation processes (Quadruple Helix systems). Here, the EU can play a significant role in bringing together the individual measures of the member states to form a greater whole.

5.1.3 MORE COORDINATION

A central question for the future orientation of European innovation policy arises: Is it even possible to develop a large-scale common strategy? Considering the departmental structure of the European Commission, political coordination is (and remains) a central topic on the agenda and is also of great importance for the (further) development of Industry 4.0. Questions of data access, data interoperability and data protection should also be clarified as should the funding of pilot projects, important educational questions and the promotion of specific skills and abilities in the population. In particular, the EU must become active in the formulation of universally recognised standards and regulations, because only the EU can provide a framework which is valid for all of Europe.

Economic integration remains one of Europe's essential strengths. This is a foundation that can be built upon. Especially the size of the market offers an enormous advantage when it comes to norms and standards. Often these opportunities remain unused – too often the actors follow their short-term national interests. Furthermore, many EU guidelines continue to allow considerable space for discretion on the national level (Enderlein/Pisani-Ferry 2014: 41 ff.). This leads to fragmentation and small-mindedness. Common standards, norms and rules could make an important contribution to more positive integration

and cohesion. And thereby contribute to more growth and social progress.

With respect to coordination, a clear European added value exists in the fact that the international umbrella organisations could be better connected on the European level. This would not only present an opportunity to prevent isolated solutions but also to limit the influence of powerful individual interests, which can afford a considerable amount of lobbying. This is the big advantage of corporatist forms of organisation, which should continue to be used and promoted by the EU. Associations can be integrated through forums which are considerably smaller than the large PPPs that currently exist and allow for easier and significantly more efficient consultations.

In the upcoming research frameworks beginning in 2020, the EU should push ahead with the development of reference architectures. A good example of an existing architecture is the "Reference Architectural Model for Industrie 4.0" (RAMI 4.0), which was proposed by the Plattform Industrie 4.0. RAMI 4.0 outlines a unified structure of terms and methods and thereby facilitates standardisation. Finally, if cooperation across sector and industry boundaries is successful, this could grow into a common "language" for Industry 4.0 (Plattform Industrie 4.0 2017b). In this area, stronger European cooperation is indispensable in order to effectively prevent piecemeal standardisation. The European Commission could, for example, continue to prioritise funding in this field.

For the sake of mission-focused funding we recommend that the upcoming work programmes of the Directorate General for Research and Innovation take a significantly more systemic approach to Industry 4.0. This should also include a new edition of the call for tender for a "Knowledge and Innovation Community (KIC) Advanced Manufacturing". The non-consideration of the consortium for the tender carried out in 2016 does not alter the fact that a KIC in this field represents an important instrument for bringing together actors from the knowledge triangle of education, science and business, who can then more easily carry this knowledge forward in a regional Quadruple Helix structure while including societal actors (diffusion).

At the same time the upcoming work programmes should show a stronger commitment to the innovation aspect. Thinkable in this context would be something like "collaborative research plus", in other words the continuation of proven principles of international and interdisciplinary funding combined with new trans-sectoral, trans-lateral approaches.

The suggestion sketched above, which would establish innovation hubs in large research centres in the framework of the strategy for digitalisation of industry and give SMEs access to computing capacity and expertise, is fundamentally worthy of support. To ensure that this opportunity is used not only by innovative SMEs, but also addresses the large portion of SMEs in traditional and less high-tech industries, cooperation with regional networks and clusters as well as regional chambers of commerce and industry is desirable. This is essential to prevent a widening of the digitalisation gap between SMEs. Such regional networks could attract increased attention to the innovation hubs and, beyond that, play an important consulting role.

Table of figures

Table of abbreviations

Bitkom	Bundesverband Informationswirtschaft, Telekommunikation und neue Medien
CRA	Constructed Regional Advantage
DARPA	Defense Advanced Research Projects Agency
DG CONNECT	Directorate General for Communications Networks, Content and Technology
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DIH	Digital Innovation Hub
EFFRA	European Factories of the Future Research Association
EFSI	European Fund for Strategic Investments
ERC	European Research Council
R&D	Research and Development
ITC	Information Technology and Communication
KIC	Knowledge and Innovation Community
SMEs	Small and medium enterprises
OMC	Open Method of Coordination
PPP	Public Private Partnership
RAMI 4.0	Reference Architectural Model Industrie 4.0
VDMA	German Mechanical Engineering Industry Association
ZVEI	German Electrical and Electronic Manufacturers' Association

Sources

Aho, Esko 2006: Creating an Innovative Europe, Report of the Independent Expert Group on R&D and Innovation, Luxembourg.

Alaja, Antti; Andersson, Lars Fredrik; Buhr, Daniel; Fink, Philipp; Stöber, Niels 2016: Innovationsstrategien in Zeiten der Digitalisierung: Ein Vergleich der Innovationspolitik in Finnland, Schweden und Deutschland, Gute Gesellschaft – Soziale Demokratie #2017plus, Friedrich-Ebert-Stiftung, Bonn.

Asheim, Björn T.; Moodysson, Jerker; Tödtling, Franz 2011: Constructing Regional Advantage: Towards State-of-the-Art Regional Innovation System Policies in Europe?, in: European Planning Studies, 19 (7), London, S. 1.133.

Borrás, Susanna; Edquist, Charles 2013: The Choice of Innovation Policy Instruments, in: Technological Forecasting and Social Change 80 (8), pp. 1.513–1.522.

Boston Consulting Group (BCG) 2015: The Future of Productivity and Growth in Manufacturing Industries, https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/?chapter=3 (1.8.2017).

Braun-Thürmann, Holger 2005: Innovation, Bielefeld.

Buhr, Daniel 2010: Chaos oder Kosmos? Die Koordination der Innovationspolitik des Bundes: Probleme und Lösungsansätze, Baden-Baden.

Buhr, Daniel 2015: Soziale Innovationspolitik für die Industrie 4.0., WISO Diskurs, Friedrich-Ebert-Stiftung, Bonn.

Buhr, Daniel 2016: Industrie 4.0 im Mehrebenensystem: Europäische Innovationspolitik zwischen Wettbewerb, Kohärenz und Kohäsion, in: Europäisches Zentrum für Föderalismus-Forschung Tübingen (Hrsg.): Jahrbuch des Föderalismus 2016, Baden-Baden, pp. 50–64.

Buhr, Daniel; Christ, Claudia; Frankenberger, Rolf; Fregin, Marie-Christine; Schmid, Josef; Trämer, Markus 2016: Auf dem Weg zu Wohlfahrt 4.0? Die Digitalisierung des Wohlfahrtsstaates in den Politikfeldern Arbeit, Gesundheit und Innovation im europäischen Vergleich, Politik für Europa #2017, Friedrich-Ebert-Stiftung, Berlin.

Bundesministerium für Bildung und Forschung (BMBF) 2014: Industrie 4.0: Innovationen für die Produktion von morgen, Berlin;

Bundesministerium für Wirtschaft und Energie (BMWi) 2014: Zukunft der Arbeit in Industrie 4.0, Berlin.

Bundesministerium für Wirtschaft und Energie (BMWi) 2015: Industrie 4.0: Volks- und betriebswirtschaftliche Faktoren für den Standort Deutschland, Berlin.

Bundesministerium für Wirtschaft und Energie (BMWi) 2016: Digitalisierung der Industrie: Die Plattform Industrie 4.0, Fortschrittsbericht April 2016, Berlin.

Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V. (Bitkom) /Fraunhofer IAO 2014: Industrie 4.0: Volkswirtschaftliches Potenzial für Deutschland, Berlin.

Direction Générale des Entreprises (DGE) 2015: Transition Numérique, https://www.entreprises.gouv.fr/numerique/transition-numerique (1.8.2017).

Enderlein, Hendrik; Pisani-Ferry, Jean 2014: Reformen, Investitionen und Wachstum: Eine Agenda für Frankreich, Deutschland und Europa, Berlin.

Engineering and Physical Sciences Research Council (EPSRC) 2015: Strategic Plan 2015, Swindon.

Engineering and Physical Sciences Research Council (EPSRC) 2017: Manufacturing the Future, https://www.epsrc.ac.uk/research/ourportfolio/themes/manufacturingthefuture/ (1.8.2017).

European Commission 2014a: For a European Industrial Renaissance, COM(2014) 14 final, Brussels.

European Commission 2014b: For a European Industrial Renaissance, https://ec.europa.eu/growth/industry/policy/renaissance_en (16.7.2016).

European Commission 2014c: "Advancing Manufacturing – Advancing Europe": Report of the Task Force on Advanced Manufacturing for Clean Production, Commission Staff Working Document, SWD(2014) 120 final, Brussels.

European Commission 2015:A Digital Single Market Strategy for Europe, COM(2015) 192 final, Brussels.

European Commission 2016: Digitising European Industry – Reaping the Full Benefits of a Digital Single Market, COM(2016) 180 final, Brussels.

European Patent Office 2017: Expert interview: The Importance of Industry Standards, http://www.epo.org/news-issues/issues/standards_de.html#benefits (1.8.2017).

European Commission 2014: Enabling Synergies Between European Structural and Investment Funds, Horizon 2020 and Other Research, Innovation and Competitiveness-Related Union Programmes, Brussels, http://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf (1.8.2017).

European Commission 2015: Digitising European Industry, https://ec.europa.eu/digital-single-market/digitising-european-industry (1.8.2017).

European Commission 2016: Digitising European Industry: Infographic on Digitising European Industry, https://ec.europa.eu/digital-single-market/en/news/digitising-eu-industry (1.8.2017).

European Commission 2017: European Innovation Scoreboard 2017, Brussels, http://ec.europa.eu/DocsRoom/documents/24829 (7.8.2017)

European Commission o. J.: Future and Emerging Technologies, http://ec.europa.eu/programmes/horizon2020/en/h2020-section/future-and-emerging-technologies (1.8.2017).

European Parliamentary Research Service (EPRS) 2015: Briefing Industry 4.0: Digitalisation for Productivity and Growth, Brussels.

Franz, Hans-Werner 2010: Qualitäts-Management als soziale Innovation, in: Howaldt, Jürgen; Jacobsen, Heike (Hrsg.): Soziale Innovation: Auf dem Weg zu einem postindustriellen Innovationsparadigma, Wiesbaden, pp. 335–354.

Gausemeier, Jürgen; Klocke, Fritz 2016: Industrie 4.0: Internationaler Benchmark, Zukunftsoptionen und Handlungsempfehlungen für die Produktionsforschung, http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Publikationen/Sonderpublikationen/INBENZHAP_dt_web_verlinkt.pdf (5.3.2017)

Hancké, Bob; Rhodes, Martin; Thatcher, Mark 2007: Beyond Varieties of Capitalism: Conflict, Contradictions, and Complementarities in the European Economy, Oxford.

Howaldt, Jürgen; Kopp, Ralf; Schwarz, Michael 2008: Innovationen (forschend) gestalten: Zur neuen Rolle der Sozialwissenschaften, WSI Mitteilungen 2 (2008), pp. 63–69.

Ittermann, Peter; Niehaus, Jonathan; Hirsch-Kreinsen, Hartmut 2015: Arbeiten in der Industrie 4.0: Trendbestimmungen und arbeitspolitische Handlungsfelder, Düsseldorf.

Klodt, Henning 2011: Zum Konzept der Leitmärkte: Eine Einführung, in: Bundesministerium für Bildung und Forschung (BMBF) (Hrsg.): Wettbewerbsfähiger durch Leitmarktstrategie?, Berlin, pp. 7–12.

Le gouvernement français 2013: La Nouvelle France Industrielle, Paris, [German version: Das Neue Industrielle Frankreich, NFI], http://www.economie.gouv.fr/files/files/PDF/web-dp-indus-futur-Allemand-29-12.pdf (1.8.2017).

Ministero dello sviluppo economico o. J.: „Industria 4.0": National Plan, http://www.amblondra.esteri.it/Ambasciata_Londra/resource/doc/2016/11/industria_4.0_national_plan_-_strategy.pdf (1.8.2017).

Ministero dello sviluppo economico 2017: Piano nazionale Industria 4.0 2017–2020, http://www.mise.gov.it/index.php/it/industria40 (1.8.2017)

Plattform Industrie 4.0 2014: Industrie 4.0: Whitepaper FuE-Themen, http://www.plattform-i40.de/sites/default/files/Whitepaper_Forschung%20Stand%203.%20April%202014_0.pdf (16.7.2016).

Plattform Industrie 4.0 2017a: Industrie 4.0 als europäischer Standortvorteil, http://www.plattform-i40.de/I40/Navigation/DE/In-der-Praxis/Internationales/EuropaeischeEbene/europaeische-ebene.html (1.8.2017).

Plattform Industrie 4.0 2017b: Normen und Standards: Eine gemeinsame Sprache für Industrie 4.0-Technologien, http://www.plattform-i40.de/I40/Navigation/DE/Industrie40/Handlungsfelder/NormenStandards/normen-und-standards.html (1.8.2017).

PricewaterhouseCoopers (PwC) 2014: Industrie 4.0: Chancen und Herausforderungen der vierten industriellen Revolution, Munich/Frankfurt a. M.; PricewaterhouseCoopers (PwC) 2015: Opportunities and Challenges of the Industrial Internet, http://www.strategyand.pwc.com/media/file/Industry-4-0.pdf (5.3.2017).

Rehfeld, Dieter 2014: Clusterpolitik im Rahmen des strukturpolitischen Mehrebenensystems: Pfadabhängigkeiten, Rahmenbedingungen und Herausforderungen für die kommunale Wirtschaftsförderung, in: Beck, Rasmus; Heinze, Rolf; Schmid, Josef (Hrsg.): Zukunft der Wirtschaftsförderung, Baden-Baden, pp. 591–611.

Reillon, Vincent 2016: EU Innovation Policy : Part I, EPRS, PE 583.778, Brussels/Strasbourg.

République Française/Direction Générale des Entreprises (DGE) 2012: Le Programme Transition Numérique, http://transition-numerique.fr/programme/ (1.8.2017).

Stehnken, Thomas 2010: The Politics of Interaction in Innovation Systems, Baden-Baden.

Technology Strategy Board (Innovate UK) 2012: High Value Manufacturing Strategy 2012–2015, Swindon.

Weimer, David L./Vining, Aidan R. 2017: Policy Analysis and Practice, 6. ed., New York.

Friedrich-Ebert-Stiftung
Published by: Abteilung Wirtschafts- und Sozialpolitik
Godesberger Allee 149/D-53175 Bonn
Fax 0228 883 9202, 030 26935 9229, www.fes.de/wiso
Orders/contact: wiso-news@fes.de

ISBN: 978-3-96250-109-9

Titelmotiv: © 123RF, Julien Tromeur
Design concept: www.stetzer.net
Typesetting: Andrea Schmidt, www.typografie-im-kontext.de
Translation and proofreading: Meredith Dale
Printed by: www.bub-bonn.de

ADDITIONAL PUBLICATIONS ON THIS TOPIC FROM THE
ECONOMIC AND SOCIAL POLICY DEPARTMENT

Policies for Innovation in Times of Digitalization:
a Comparative Report on Innovation Policies in Finland, Sweden and Germany
GOOD SOCIETY – SOCIAL DEMOCRACY #2017 PLUS – 2016

Social Innovation Policy for Industry 4.0
GOOD SOCIETY – SOCIAL DEMOCRACY #2017 PLUS – 2015

Industry 4.0: New Tasks for Innovation Policy
GOOD SOCIETY – SOCIAL DEMOCRACY #2017 PLUS – 2015

FRIEDRICH EBERT STIFTUNG

For these and other publications:

www.fes.de/wiso